

1956

LAKE STATES FOREST EXPERIMENT STATION

- ST. PAUL, MINNESOTA
- M. B. DICKERMAN, DIRECTOR

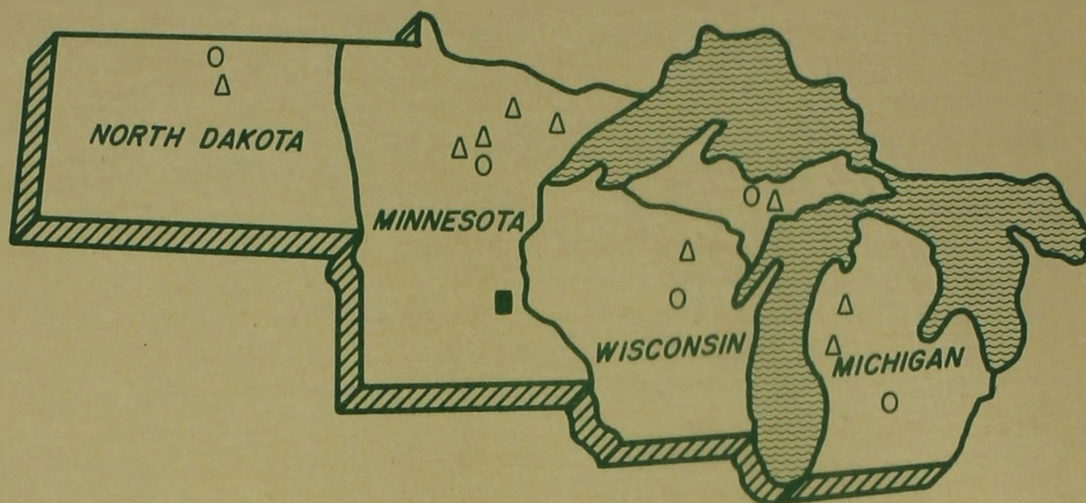
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Forest Diseases
Forest Economics
Forest Insects
Forest Management
Forest Products Utilization
Watershed Management
Wildlife Research

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THE 1956 ANNUAL REPORT
of the
LAKE STATES FOREST EXPERIMENT STATION

H I G H L I G H T S O F 1 9 5 6

This is the 33rd annual report of the Lake States Forest Experiment Station. Each year for 32 years the staff have summarized their major activities and reported on progress of specific studies. Once again we will try to do this, covering briefly the wide range of all the Station activities.

Nineteen hundred and fifty-six saw numerous developments of special significance in the Station's program. Plains forestry research was reactivated in North Dakota. Twenty years ago a forest research program was initiated in that area, but during World War II it was terminated. Now in the making is a program centering on the problems of tree planting and management. Another development of major importance was the establishment of a Watershed Management program under the Station's direction. This field, much neglected for many years, should now receive the attention it deserves in forest research activities of the Lake States.

In Michigan two research programs were strengthened. The forest management projects in Upper Michigan are being accelerated. Emphasis there is being placed on problems of managing second-growth hardwoods and swamp conifers. In Lower Michigan a project dealing with forest insect problems of coniferous plantations was initiated. Two staff members have been assigned to this work, and it is expected that greater attention to plantation insects will be needed as the planting program advances.

Other Station activities, too, received greater attention. In Forest Economics new projects in marketing, land use, and the economics of forest management were undertaken. Forest insect and disease surveys were strengthened, and the related research work was accelerated.

While all of these activities were receiving attention, progress in work already under way was most gratifying. During 1956 the Station published over 80 reports on research findings. Other organizations and individuals cooperated on many of these reports. Publications included a

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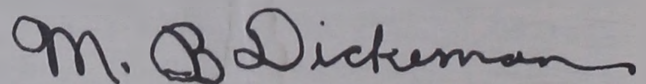
bulletin on Pruning Pine Plantations in Michigan, a Guide for Selecting Superior Trees and Stands in the Lake States, a report on the Forest Resources of North Dakota, and five Forest Pest Leaflets. A comprehensive bulletin dealing with Forest Nursery Practice in the Lake States will be available early in 1957.

Reviewing the status and balance of the present research effort in the Lake States, certain weaknesses are evident. The almost total lack of forest and watershed management research in the Driftless Area (southwestern Wisconsin and southeastern Minnesota) is most serious. This Driftless Area is becoming more and more a source of timber for wood-using industries. Also, it has a long history of flash floods; erosion on the hilly, nonglaciaded slopes; and grazing damage to woodlands. But what to do to overcome this problem and how to do it can best be determined by a comprehensive forest research effort.

Another pressing need is to provide adequate field laboratory facilities. Keeping forest research in-the-woods is commendable. But with such orientation must go a program for providing adequate laboratory and housing facilities. In many areas the Station is lacking in such facilities. This is especially serious in insect, disease, and genetics research.

Some of the most significant regional developments in 1956 were the announcements of plans for establishing new forest industries and the expansion of some existing plants. Once a seriously depleted forest area, the Lake States are showing many signs of a stronger forest economy--more timber, more industries, and more employment. In facilitating these trends, the Station's contributions have been numerous. Providing forest resource information for prospective industrial expansion has become a big job. Getting together technical forestry groups as a means of orienting research efforts, of disseminating research findings, and of marshaling all forces for strengthening forest research has received much attention at the Station. Over a dozen group meetings, each with 15 or more key foresters in attendance, were sponsored by the Station and proved highly successful. More of these are scheduled for 1957.

In brief, these are some of the events of significance in the Station's activities during 1956. In the fast-moving, highly technical field of forestry, it is more and more evident that basic knowledge about the forest community is fundamental to maintaining high productivity of forest lands--now and in the future.



M. B. Dickerman, Director

W A T E R S H E D M A N A G E M E N T

by Sidney Weitzman, Division Chief

Watershed Research Program Initiated

In 1956, a new Division of Watershed Management Research was established at the Station. The need for studies of the many watershed problems associated with the use made of the forests was recognized many years ago. The Station pioneered in this field of research when it started a limited program of watershed management research in the early thirties. However, all fieldwork was shut down with the advent of World War II when funds were diverted to the war effort. Reactivation of watershed studies after a lapse of 15 years was the result of a growing interest in the water resource in the Lake States and a realization that research in this field can no longer be ignored.

Watershed studies are especially significant in the headwater reaches of the Mississippi River. This forested area is vitally important for protecting the headwaters of rivers that carry the commerce, generate power, provide water for domestic and industrial use, and sometimes create damaging floods.

Watershed Problem Areas

Water problems in the Lake States are as diverse as its soils, topography, climate, and underlying geology. Each of these factors influences water behavior just as it helps to determine timber type and growth. To be meaningful, the research program needs to be tailored to conditions in the different portions of the region. A brief description of the more important problem areas will indicate the types of research necessary to solve some of the existing water problems.

The northern forest region.--This is a heavily forested area underlain by glacial till. It is an area of lakes and swamps, with level to gently rolling topography. Though rarely plagued by floods and erosion, it is, nevertheless, a most important watershed area. The behavior of its streams may be less erratic than those in the more hilly sections, but heavy use by pulp mills, fishermen, and tourists have caused conflicting interests to develop. These differences will not be resolved without a fund of sound information to call upon.

One problem concerns the efforts to drain millions of acres of marsh and bogs to convert them to agriculture. Timber producers also have experimented with bog drainage in an attempt to increase timber growth. On the other hand, these same areas are highly productive as game habitat, and sportsmen and vacationists can strongly defend maintaining

them in their wild state. Some industries are planning to use water from bogs. Farmers are increasing the acreage under irrigation. Yet no one knows the value of these vast bodies of water as a source of ground water recharge or as a stabilizing influence on streamflow.



What is the hydro-logic effect of swamp drainage in this northern Minnesota black spruce forest?

This northern forest region appears to be adequately supplied with water for the present--if properly managed. However, with demands for water increasing, it is wise to collect basic information which will help resolve some of these conflicting interests in use. Sound information is needed on the interrelations of forest cover and water quality, ground water recharge, streamflow, and base flow. We will then have the information necessary to manage this vital resource intelligently. The manner in which these forests can be made to yield a sustained supply of good water will affect the lives of millions of people.

The Driftless Area.--The hilly, nonglaciaded portion of southern Wisconsin and Minnesota represents the region's most spectacular watershed problem area. The steep hillsides are underlain by a highly erodible loessal soil. Unwise clearing of the protective forest cover, accompanied by woodland grazing and improper road location, has set the stage for the Lake States' most marked erosion, sedimentation, and flood problems.

Flood damages in the Mississippi River drainage basin within the State of Minnesota alone cost taxpayers over \$3,500,000 a year. These flood waters carry with them most of the topsoil. Tremendous volumes of sediment are poured into the Mississippi by streams draining the area.

Affected in the hill farms, as well as in communities downstream, are the jobs of the people, their standard of living, their security against floods, and even the existence of some of their industries.

Soil erosion in the Driftless Area of southwestern Wisconsin. This is the result of improper grazing and inadequate forest cover.



Other problem areas.--Two other problem areas need special study: (1) The red clay lands adjacent to Lake Superior, and (2) the Traverse City-Cadillac area of Lower Michigan. The soils of the red clay lands are heavy clays which are highly erosive when exposed. A marked increase in erosion and many cases of land slippage have been noted in the past decade. Road construction, logging roads, and skid trails are probably the most serious causes of accelerated erosion in the area. Methods of locating, constructing, and maintaining roads for harvesting a timber crop without destroying water values need to be developed.

The sandy soils of the Traverse City-Cadillac area are subject to severe erosion by both water and wind when exposed. Sandblows and gullies form a conspicuous part of the landscape. Establishing vegetation on these difficult planting sites will help stabilize such areas.

First the timber, then the soil, and now the oil have been exploited in this area near Reed City, Mich. The stabilization of such wind-blown sands is a local problem in many places in the Lake States.



Problem Analysis Made

In 1955, as a preliminary to planning a program, the Station and Michigan State University made a problem analysis of the watershed management research needs in the forests of the Lake States. This analysis brought together much of the existing information, pointed out where data were lacking, and focused attention on some of the existing watershed problems. The findings of this report will help lay the foundation of a sound research program.

Personnel Selected

Personnel for the new division are being lined up. Sidney Weitzman, formerly with the Northeastern Forest Experiment Station, is chief of the division. J. H. Stoeckeler, for many years with the Station, joined the watershed management staff. Roger Bay, formerly with Region 1, was assigned to the Headwaters Research Center. To date, this constitutes the staff.

Studies Started

The first series of studies was started at the Headwaters Research Center in Grand Rapids, Minn. To get some background on water behavior in the northern forest region, some preliminary studies were begun this fall on amount of snow accumulation, snow disappearance, soil freezing, and soil moisture changes in several forest types. The purpose of these studies is to provide us with sufficient basic information to determine what changes can be made in forest cover to increase the efficiency of our watersheds.



Weather stations such as this one in the Northeast are needed in future studies of snowpack in the Lake States.

The Jobs Ahead

The three major jobs ahead are to recruit and train personnel, select research areas, and expand to other problem areas.

In starting a new line of research, one of the first jobs is to recruit and train technicians. There is a scarcity of qualified men in the field of watershed research.

After more background has been accumulated, experimental watersheds will be selected for conducting long-range watershed studies. These will take careful selection, since these watersheds must represent conditions in the problem area. Geology and soils, as well as forest cover conditions, will be considered.

In addition to rounding out the program in the northern forest area, the Station recognizes that work in other problem areas cannot be neglected. There has been considerable interest in starting research work in the Driftless Area and some studies are now being considered.

F O R E S T P R O T E C T I O N

(Diseases--Insects--Fire--Wildlife)

To devise methods of intensive forest management for maximum quality production is a major goal of forest research. But that is not enough. Foresters must also wage incessant war on the enemies which kill and deform trees and reduce growth and quality.

Within the past three decades, concentrated effort by many groups in the Lake States has resulted in a system of fire protection that has reduced fire losses to one-tenth of what they were earlier in the century. Study is still needed, however, on various fire problems, particularly in regard to coniferous plantations. The uses of controlled fire, too, have yet to be explored.

For the past few years the Station and its cooperators have been gathering their forces for a similar assault on forest insects and disease, which now are far more destructive than fire. Some of the painstaking and time-consuming research required to understand and control these enemies is now under way.

Our forest wildlife presents a different problem. Research in this field has a twofold purpose: To ensure adequate food and cover for our birds and mammals, and to prevent them from damaging the young forest growth.

Forest Insects

by H. J. MacAloney, Division Chief

During the past year insect research activities of the Station were further strengthened by new projects and new personnel.

To implement studies on plantation insects in Michigan, Dr. William E. Miller was added to the staff of the Lower Peninsula Research Center and Arnold T. Drooz was transferred from Minnesota to the Center. Under their guidance insecticide studies for the control of the European pine shoot moth, the most important plantation insect pest in Michigan and Wisconsin, were initiated. These studies will be broadened to cover other plantation insects, particularly the white-pine weevil and pine sawflies.

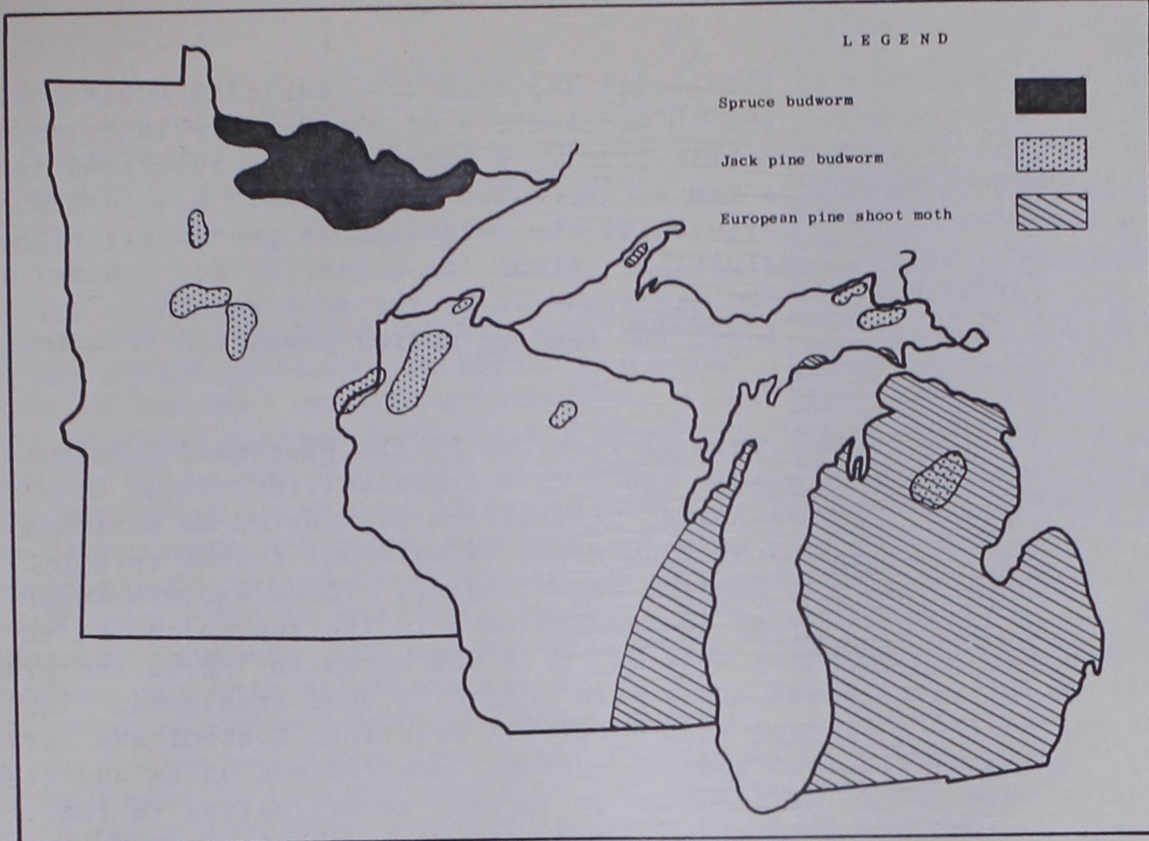
Special attention is being given to the forest management aspects of the spruce and jack-pine budworm problems. A step in this direction was made by the transfer of an entomologist, Harold O. Batzer, from St. Paul to the Headwaters Research Center in northern Minnesota. He will work with other research personnel to develop guides for sound management practices which can be used by the forest manager to reduce forest insect damage. Priority has been given to studies on the spruce budworm.

Plans have been made and construction has begun on the new insect field laboratory building at the Kawishiwi Experimental Forest in northern Minnesota. Much of the summer research on forest insects will be conducted at this laboratory.

Early in the year the usual annual meeting of entomologists was held to develop and improve uniform insect detection survey techniques. As a result, standard procedures were used by many organizations in the Lake States this year in evaluating infestations of several major forest insects.

In November, 35 foresters and entomologists gathered to study the jack-pine budworm problem in the region. The extent of the 1956 infestations, the need for possible control in 1957, and the present and future research plans of the Universities of Minnesota and Wisconsin and the Station were discussed.

Although the research program dealing with the major forest insects is progressing, more attention is needed on certain aspects such as: The manner in which insects may act as vectors of disease; the location or development of individual trees, races, or species of trees showing resistance or nonsusceptibility to insect attack; and the introduction of parasites or predators as a means of biological control.



Infestation areas of three major forest insects in the Lake States, 1956

Saratoga Spittlebug Research Program Nears Completion

Studies of the Saratoga spittlebug as a pest in red pine and jack pine plantations are nearly completed and a bulletin is in preparation. Although this pest once threatened to devastate a large portion of the pine plantations in the Lake States, fruitful research has resulted in the development of routine control procedures whereby tree damage can be almost completely eliminated. Through these procedures constant vigil can be maintained over thousands of acres of pine plantations in northern Wisconsin and Upper Michigan so that dangerous infestations can be detected and controlled.

Critical analysis of insect populations and of host damage data from permanent study plots has shown that the danger of infestation can be adequately rated by considering the insect population and the host size and density. For the past 3 years a new appraisal technique has been evaluated by extensive field testing. The technique involves measurements of (1) the nymphal population, expressed as the average number of nymphs per milacre (A), and (2) the host size and density (B), expressed as a product of the average tree height (in feet), the average number of living whorls per tree, and the average number of stems per acre. It has been determined empirically that when the average number of nymphs per "tree-unit" (as each unit of the host size and density product has been labeled)

exceeds 1.65, the feeding scar level (X) from the resulting adult population will exceed 60 scars per 10 centimeters of the 2-year-old internodes. Serious deformity occurs at this level. A straight line relationship between these various factors can be expressed as follows: $X = (A/B)K$, where $K = 36$. This is a revision of the relationship previously reported, and is a more realistic evaluation. Since the criterion for control in a particular infestation is the magnitude of X, the area should be treated if X exceeds the critical level (60 feeding scars) predicted from the nymphal samples.

Nymphal population surveys were carried out by the Wisconsin Conservation Department on State and private lands with appraisal techniques developed by the Station. On Federal lands, plantations designated as probably containing high populations were surveyed by national-forest personnel under the supervision of a Station entomologist. These surveys began on June 20, when the majority of the nymphs were in the fourth and fifth instars, and were completed by July 2. Of 8,056 acres in the 33 red pine plantations surveyed, 2,935 acres were judged to need treatment. This acreage was aerially sprayed with a DDT-oil solution; control was satisfactory. Based on the 1956 nymphal surveys, populations on an additional 3,146 acres were deemed high enough to warrant re-evaluating in 1957. In addition, the 1955 and 1956 adult sweep surveys of plantations previously sprayed or just becoming susceptible have raised the total acreage to be nymphal-surveyed in 1957 to 12,245 acres. Because natural factors cause considerable winter and early spring mortality, it is expected that the acreage to be treated will be somewhat less.

Larch Sawfly

Tree Mortality Increasing

The larch sawfly continued in epidemic status in northern Minnesota. Moderate to heavy defoliation occurred in widely separated stands in northern Michigan and Wisconsin, showing an increase over that reported in 1955.

The better tamarack sites in northern Minnesota were surveyed in September to determine the extent of tree mortality due to the repeated defoliation since 1949. Mortality was first reported in "off-site" tamarack stands in northeastern Minnesota in 1954 and appeared in some of the better stands to the west in 1956. Mortality was recorded on 1/10-acre circular plots established in 1956 at or near permanent observation points in the area of defoliation. Tree mortality ranged from 0 to 22 percent; the higher mortalities occurred on the poorer sites. Much of the mortality was in the 2-inch diameter class. Some of the trees may have been killed because of competition, but the possibility of other causes such as high water is eliminated since associated species, such as black spruce and cedar, did not die. All stands within the area suffered heavy to complete defoliation in 1956. It is apparent that trees growing on the poorer sites cannot endure repeated defoliation as well as those growing on the better sites. Tree mortality was not reported from Michigan or Wisconsin.

Laboratory testing equipment for determining lethal dosages of insecticides.

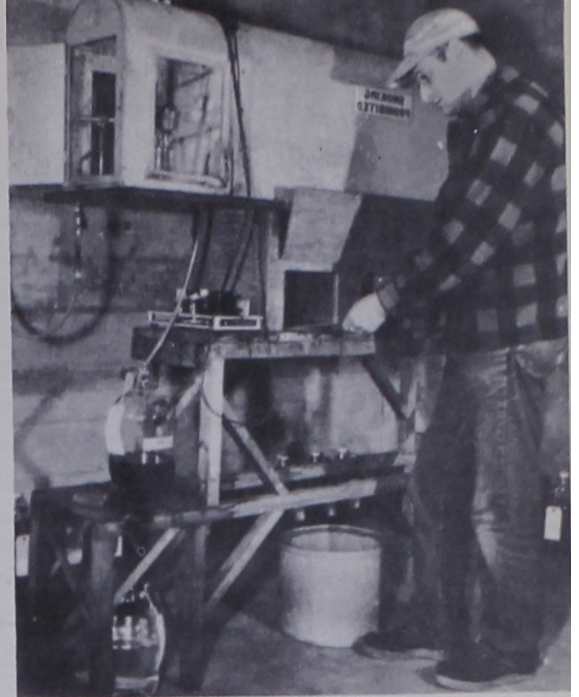
Laboratory tests, begun on the larch sawfly in 1955, were continued in 1956. Oil solutions of the most promising toxicants, malathion and benzene hexachloride (BHC), were tested as was DDT which is commonly used in forest spraying. Known amounts of the insecticide solutions were applied to larval groups--mixed first and second instars, mixed fourth and fifth instars, and late fifth instar. DDT did not kill at low dosages, but both malathion and BHC were effective as contact insecticides. However, as the larvae developed from first to late fifth instar it became increasingly difficult to kill them with low insecticidal concentrations. No field tests were made, but BHC appeared to be an excellent insecticide for forest spraying. Malathion, which has a short residual action, may be used on ornamentals and on other trees where more than a single application can be easily made. Fieldwork on larch sawfly studies has been completed and a departmental bulletin is in preparation.

European Pine Shoot Moth Insecticidal Tests Under Way

Control tests against the European pine shoot moth--the most important pest of red pine in Lower Michigan--were started in 1956 in cooperation with the West Ottawa Soil Conservation District. These tests were designed to evaluate the costs and effectiveness of various control measures.

A number of combinations of spray treatments were applied on 1-acre plots in two different red pine plantations in late April and early May and repeated on similar plots in late June and early July. Several of the

A drenching spray, discharged with hydraulic equipment, will control the European pine shoot moth satisfactorily.



methods were also tested on Scotch pine. Insecticides used were DDT and malathion; the rates of application ranged from 5 to 400 gallons per acre, depending on the type of equipment. The concentrations of DDT varied from 2 to 8 pounds per acre. One drenching spray, using 2 pounds of actual DDT in 100 gallons of water 1 week after the moths started flying, or two repeat sprays of the same dosage in less than drenching quantities at 7- to 10-day intervals after moth flight began, resulted in 95 percent control. The drenching treatment required about a tenth of a gallon of spray mixture per foot of tree height. The equipment used included hand sprayers, hydraulic sprayers, mist blowers, fogging machines, and airplanes. Shearing off the infested buds, on both red pine and Scotch pine, also proved to be an effective measure of control. This method is time-consuming if there are more than 5 or 6 infested buds per tree. However, it is a practical method when only a few buds are infested or when it can be integrated with regular shearing work for Christmas tree shaping. The newly infested buds can be detected in late July by the presence of brown needles and excess pitch at the base of the bud clusters.

Spruce Budworm Threat Continues

The broad research program on the spruce budworm continued. Additional data on parasites and on the trends in budworm populations were obtained through intensive collections and rearings of larvae and pupae from 3 of the 5 permanent study areas established in 1955.

The 1955 egg survey indicated a low to medium hibernating population in all the study areas as well as over most of the spruce-fir type in Minnesota. Low winter mortality, averaging only 18 percent, resulted in the emergence of a major portion of the brood in May. Below-normal temperatures during May delayed development for about 3 weeks. However, a hot, dry June accelerated development, and the adult stage was reached only 10 days later than in 1955. The reduction in population from the beginning of spring activity was approximately 85 percent; half of this reduction was attributed to parasites, while the remainder was due to predators, diseases, and natural causes. Under normal conditions, the 15 percent which developed to adults is sufficient to increase the 1957 population severalfold.

The adult females had a high fecundity, indicating an increase in egg deposition and consequently the possibility of an increase in both the severity and extent of defoliation in 1957. This possibility was strengthened through an intensive egg survey, which extended throughout the northwestern half of the spruce-fir type in Minnesota; the number of egg masses at the collecting points averaged 19 more than in 1955. Collections at roadside stands were supplemented in remote stands by air travel.

Aerial surveys showed heavy defoliation along the Canadian border in a large area extending south to Lake Vermilion in the central part of St. Louis County, on a Wind Lake island in Lake County, in an area immediately

Heavy spruce-budworm feeding and top killing is already apparent in northern Minnesota.

north of Nett Lake in Koochiching County, and in the Northwest Angle in the Lake of the Woods. Almost complete defoliation was found on the Wind Lake island, and it is possible some tree mortality may develop there in 1957. Light to medium feeding was evident farther south than in 1955. In general, the infestation has increased in severity.

Jack-Pine Budworm Control Contemplated

The jack-pine budworm infestations in Wisconsin and Minnesota have increased in both extent and severity. The Mosinee Paper Company and the Wisconsin Conservation Department aerially sprayed 22,000 acres of jack pine type. In Minnesota 200 acres were sprayed experimentally by the Office of the State Entomologist and the University of Minnesota.

Larval, pupal, and egg surveys were made by the Wisconsin Conservation Department on State and private lands. Based on these surveys, approximately 203,000 acres--primarily in the northwestern part of the State--have been designated for possible control action next year. In addition, aerial and ground surveys by the Lake States Forest Experiment Station indicated that treatment is needed on 11,500 acres on the Washburn Ranger District of the Chequamegon National Forest. Surveys by the Office of the State Entomologist of Minnesota showed that 100,000 acres in north central Minnesota contained budworm populations heavy enough to consider control. Additional surveys will be made in all these stands in both States next spring to determine if natural control factors have reduced the acreage needing treatment.

The infestations in Luce and Chippewa Counties in the Upper Peninsula of Michigan declined still further in 1956, primarily because of parasites. Collections begun in 1953 showed a gradual increase in number and species of parasites. In 1955 the aggregate parasitism, excluding that of the eggs, was 56 and 66 percent in Luce and Chippewa Counties, respectively. Pupal parasitism made up the highest percentage, showing a marked increase over that in 1954. Apechthis ontario, Phaeogenea hariolus, and Itoplectis conquisitor were the main pupal parasites. Larval collections were made in 1956, but the larvae have not yet been dissected.



Boxelder Insects in Shelterbelts

One of the critical forestry problems in North Dakota is the blight of boxelder, a species of great importance in the shelterbelt program. This blight is widespread in North Dakota and adjacent States and Provinces. It appears to be of major importance in the nurseries, and it has also been found in the field plantings. The typical symptoms are small curled chlorotic leaves on the new shoots; not all the leaves on the shoots are affected. North Dakota foresters believe the growth of the seedlings is stunted by the blight.

Examinations were made, both in the nursery and in the field. In all cases a small lepidopterous larva was found boring either in the terminal bud axis or in a lateral leaf axis. Three possibilities are suggested: (1) The condition is a physiological response of the plant brought on by the boring activity of the insects, (2) a virus, bacteria, or fungus is introduced by the insect, or (3) the insect is incidental to the disease. If a virus is present it may be transmitted by insects such as aphids, plant bugs, leafhoppers, or thrips.

In cooperation with the North Dakota School of Forestry, space was set aside at the Bottineau Nursery to study the problem. Emphasis in the beginning will be on the entomological phase, with later integration with pathology and genetics. The life cycle of the insect and the determination of its connection, if any, with the disease will be studied.

Plans for 1957

The biological and ecological studies on the spruce budworm will be continued. Studies of cutting practices which will reduce infestations in spruce-fir stands will be expanded, and similar studies will be developed in jack pine stands infested by the jack-pine budworm. The European pine shoot moth insecticidal research to develop more reliable control measures will be continued; some of the newer insecticides will be tested, and it is hoped that preliminary testing can be carried out on a large acreage of forest plantations. Spruce budworm aerial surveys will be continued and, if conditions warrant, will be expanded. Research in aerial surveys is planned in cooperation with the Beltsville Forest Insect Laboratory to develop more accurate survey observational techniques applicable to Lake States topography. Supervisory assistance will be available to the State agencies if large-scale control projects are carried out. Manuscripts on the larch sawfly and the Saratoga spittlebug will be submitted for publication.

Forest Diseases

by Ralph L. Anderson, Acting Division Chief

Funds available for forest disease research and surveys were increased during the past year. Thus we were able to increase the staff to five technical men and make some changes in our program. During the year Gerald W. Anderson and Neil A. Anderson were added to the staff in St. Paul. Dr. Eugene P. Van Arsdel was assigned to the white pine blister rust microclimate study at Madison, Wis., replacing Dr. John R. Parmeter. The latter is being transferred to Rhinelander, Wis., to work on northern hardwood decay problems. These increases in personnel have enabled the Station to expand its effort on going projects and to initiate the new project on northern hardwood decay.

Although considerable progress has been made in developing the Station's disease program, many complex problems cannot be given adequate attention. The inherent complexity of disease problems and the severe losses caused justify an even greater effort. A rough estimate indicates that the current growth loss due to diseases is over 150 times as great as that caused by fire. To a large extent, this is due to lack of disease prevention and control measures.

Some of the more important problems not receiving sufficient attention at present are:

1. The complexities involved in the Hypoxylon canker problem indicate that more rapid progress would be possible if pathologists could give it more study.
2. The increasing acreages of forest plantations in the region are becoming a valuable source of wood. However, disease problems are developing, especially in red pine. These problems call for more intensive study than present staff and facilities permit.
3. It is estimated that decay accounts for 70 percent of the growth loss due to diseases. A one-man program in northern hardwoods cannot cope with the complex problems involved.
4. An unknown disease or disease-insect complex is prevalent on North Dakota boxelder, one of the principal species planted in that State. The cause and possible control measures should be determined.
5. There is an increasing demand for better evaluations of the current impact of diseases and their potential for future damage. A considerable increase in survey activity is needed to provide adequate information.

The disease research division is concentrating present efforts on Hypoxylon canker, oak wilt, blister rust, white pine root rot, and the new hardwood

decay study. Some other diseases have been given limited attention. In addition, cooperative projects involving some financing by the Station are under way at the University of Minnesota, University of Wisconsin, and Michigan State University. Activities on Station projects in 1956 are summarized briefly in the following pages.

Hypoxyton Canker Causes Serious Damage

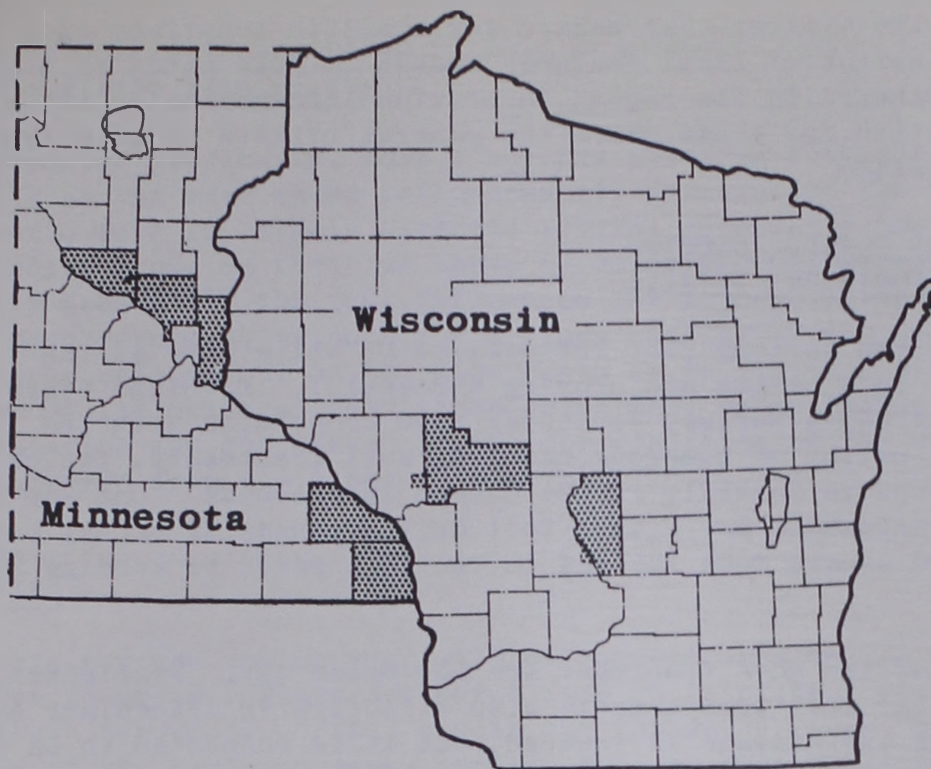
Most of the effort on the Hypoxyton canker problem has gone into research on the relationships between various stand and site characteristics and damage caused by the disease. The pulp and paper industry, the Iron Range Resources and Rehabilitation Commission, and the University of Minnesota have made major contributions. Currently, most of the work involves maintaining and remeasuring permanent plots and thinning studies established in previous years, and evaluating results. To supplement the research program, a Hypoxyton survey was initiated this past year to determine the amount of damage caused by the disease and trends from year to year in canker prevalence and mortality. Research and survey results are as yet very tentative.

The survey indicates that canker kills 1 to 2 percent of the total volume of aspen timber annually. This means the loss may be as great as 1,400,000 cords per year. The survey results also suggest that the amount of infection varies appreciably from year to year. Plot data obtained in Minnesota during the past 7 years indicate a high prevalence of infection in 1950, a decided decline during the early 1950's, then an increase to a high level in 1955, and a downward trend again in 1956. Research results during the year have strengthened appreciably previous evidence that stand density is a principal factor influencing the amount of infection and damage caused by the disease. Further evidence has also been found indicating that most infections originate at the base of branch stubs, and that there is considerable variability in the rate at which cankers kill trees. Stand composition may have an important influence on infection, but available data have not given consistent results. Additional study is needed before these relationships can be interpreted properly.

Much of the difficulty encountered in solving the Hypoxyton canker problem stems from an insufficient knowledge of the biology of the fungus. A cooperative study on one phase of this broad subject is in progress with the University of Minnesota. Additional studies will be undertaken by the Station to determine the significance of the branch stub relationship and the principal biological factors influencing establishment and growth of the fungus in the host.

Oak Wilt Rate of Spread Studied

Progress is being made in the surveys to determine the pattern of oak wilt spread--that is, is it rather constant from year to year or does it



The oak wilt rate-of-spread survey is conducted in the Wisconsin and southeastern Minnesota areas indicated on the above map.

fluctuate--and the average rate at which the oak wilt is invading the oak type. Both local spread, primarily through root grafts, and overland or long-distance spread are being studied. Results for 1955 and 1956 indicate that approximately one new infection center per 60 acres of oak type is established per year. Over 50 percent of the existing centers of infection increased in area during the year, with an average radial spread of 3.5 feet for all centers. This survey will be continued to obtain more information on infection trends.

The Prevalence of
White Pine Blister Rust
is Related to Microclimate

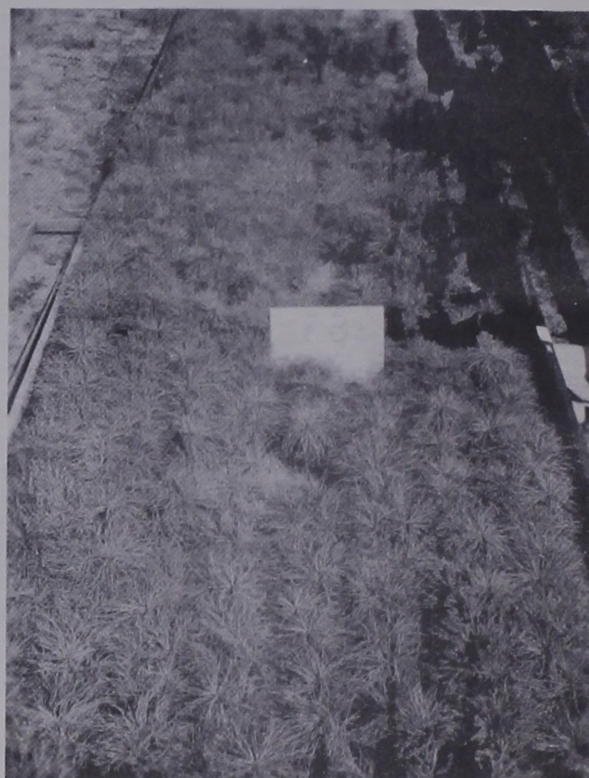
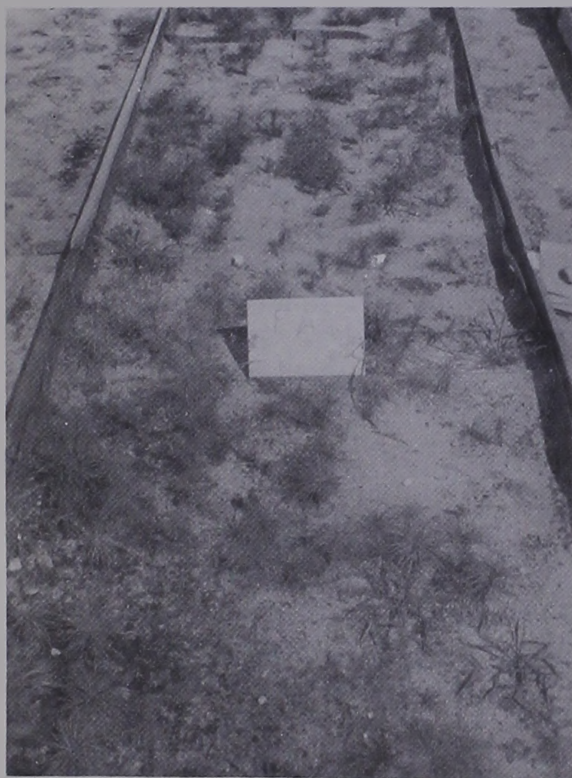
In the southern part of the region severe blister rust infection is usually limited to localized areas. A cooperative study with the University of Wisconsin has provided further evidence that this distribution pattern is correlated with the microclimate prevailing in such localized areas and that microclimate can be predicted on the basis of topographic features and tree cover. The rust is favored by the cool, moist microclimates. These are found on north exposures, in depressions, behind barriers which act as cool air dams, in small openings in the forest canopy, and in areas where the canopy is broken. A primary objective is to develop a simple

system for rating the blister rust hazard for specific locations on the basis of the combination of local features present. This study is also being extended northward in the region to provide information on the microclimate situation for areas where the general climate is more favorable for rust infection.

White Pine Root Rot Control Studies Continue to Give Promising Results

Efforts to control the serious root rot disease of white pine at the Chittenden Nursery in Michigan are proving successful. Michigan State University and Chittenden Nursery personnel have cooperated with the Station in the evaluation of numerous chemical soil treatments, two of which have been found to markedly reduce damage in seedbeds. One and one-half ounces of formaldehyde per square foot or 1.6 pounds of methyl bromide (MC-2) per 100 square feet applied to the soil prior to seeding have been effective.

Large-scale tests of the MC-2 treatment are now under way. Preliminary results indicate that this treatment is also effective in transplant beds. So far the cause of the disease is unknown, but it is suspected to be a fungus, a nematode, or a fungus-nematode complex. Michigan State University and the Station will cooperate in determining the cause.



White pine root rot at Chittenden Nursery controlled by preseedling soil treatment. Left, check plot has suffered severe root rot losses. Right, plot treated with 1.6 pounds of methyl bromide per 100 square feet supports good stand.

Work is Continuing on Races of White Pine Blister Rust

As reported previously, this study has provided evidence of genetic variability in the rust which influences its reaction on the ribes hosts. At present, work is largely directed towards developing test materials and methods for use on the pine hosts to determine whether the genetic variability present in the rust influences its pathogenicity on the pine hosts. The development of methods for uniform testing of the reaction of different rust collections on the pine hosts is in itself a difficult task because of the critical conditions which must be maintained for effective inoculation and the change in nuclear condition of the rust when it is transferred from the ribes to pine host.

Plans for 1957

Efforts for the coming year will be concentrated on the going studies referred to above. Plans are being made to initiate a study of decay in the northern hardwoods. Plans are in the formative stage, and the specific phase of the hardwood decay problem has not been selected.

Forest Wildlife

by L. W. Krefting, Fish and Wildlife Service

Wildlife is one of the most important resources of Lake States forests. It provides aesthetic values and recreation for the people of the region and is a source of economic benefit resulting from the expenditures of sportsmen. To assist in maintaining wildlife populations at a maximum consistent with the cover and food supply and to prevent destruction of the young forest growth are the goals of this field of research.

By cooperative agreement with the U. S. Fish and Wildlife Service, the Station has a biologist, L. W. Krefting, assigned to it by the Section of Wildlife Investigations on Public Lands, Branch of Wildlife Research. Other public agencies and the Quetico-Superior Wilderness Research Center cooperate on many of the studies.

The research carried on concerns the effects of wildlife on the forest and the influence of silviculture practices on wildlife populations. A few of the findings during 1956 on two of the current projects are discussed below.

Factors Affecting Yellow Birch Reproduction

On the Upper Peninsula Experimental Forest at Dukes, Mich., 8 exclosures (3x3x2 feet high) and a similar number of control plots (3x3 feet) were

were established on the 20-acre yellow birch cutting area. Half of the area was disked and half undisked. Four of the fenced plots ($\frac{1}{2}$ -inch hardware cloth) were made mouse-proof, and four had about 2 or 3 inches at the ground line left open to permit mice to enter. The objectives of the study were to measure the effects of field mice, chipmunks, red squirrels, snowshoe hares, and white-tailed deer on the early growth of yellow birch seedlings. So far, seedlings have been damaged and killed by hares and deer, although the greatest losses have been from frost. Within the exclosures mortality was about 10 percent, but on the unfenced plots it was about 3 times as high. Mortality on the unfenced plots on the disked half of the area was caused by the following factors: Frost, 12 percent; frost and deer, 12 percent; deer, 3 percent; and unknown causes, 6 percent. On the undisked part of the area frost accounted for the loss of 21 percent of the seedlings and frost and deer together 11 percent.

Deer Browsing Stimulates Mountain Maple Regrowth

On the Superior National Forest 50 clumps of mountain maple have been measured each fall and remeasured each spring to determine the amount of browsing the species can withstand and still recover satisfactorily. Since the fall of 1952, deer have consumed the following percentages of the annual growth each yarding period: 50, 84, 88, 88, and 93 percent. When 50 percent of the annual growth was taken during the winter of 1952-53, the regrowth decreased by 17 percent. However, severe browsing during each of the following winters (84 percent or more of the annual growth) and stem breakage produced increases of 5, 11, 16, and 17 percent.

Other Projects

Other research assignments in 1956 included studies on: (1) The use of repellents for protecting conifer plantations from damage by deer, snowshoe hares, and mice, (2) the effects of birds and mammals on the establishment of trees and other woody plants following fire in a mixed conifer type, (3) the effects of deer and moose browsing and snowshoe hare clipping on forest plantations and other range vegetation, and (4) silvicultural practices in mixed coniferous swamps in relation to the establishment of tree reproduction and shrubs of value to deer and other wildlife.

Plans for 1957

Work will be continued on all of the projects discussed above. Some new assignments will be started where the necessary cooperation can be obtained. To be published soon are articles on factors affecting the early growth of yellow birch seedlings, and the effect of deer browsing on reproduction in the northern hardwood-hemlock type.

Forest Fire Research

by Lloyd LaMois, Forester

Foresters are becoming increasingly aware of the close link between fire control and other forest management activities. The impact of silvicultural treatments, harvest methods, and forest use upon fire control considerations calls for an integration of protection from fire into management practices. The Station has one man assigned to this important field of research.

Measurement of Fuels in Plantations

One phase of forest management, the establishment and management of forest plantations, has particularly significant fire control implications. Because of their relatively high values in both initial investment and growth potential, plus an inherent susceptibility to fire damage, the increasing acreages of pine plantations in the Lake States have developed into a special fire control problem. During the 1956 field season, a study was initiated to measure the changes in fuels that occur in the early development of red pine plantations. Fuels were collected from 115 plots distributed over a range of ages and sites to determine the type and quantities of fuels that are present. From this study and other similar ones to follow, recommendations for management practices to minimize the potential for severe fire damage in Lake States plantations will be developed.

FOREST ECONOMICS

by R. N. Cunningham, Division Chief

The Station's work in economics can be reviewed under three general headings:

1. Forest Survey--which has to do with the assembling and analysis of statistics on forest resources and forest industries.
2. Marketing Studies--exploring existing and potential markets, as a step toward increased utilization of some species and grades of wood.
3. Other Economic Studies--currently focused on land-use problems and production costs. From time to time studies on other problems such as taxation, credit, land ownership, and valuation are also made.

Forest Survey

The forest survey project has reached another turning point in its progress. The first regional timber survey in the Lake States was made in the 1930's. After World War II a second survey was begun in Michigan, Wisconsin, and Minnesota, and initial surveys were made in the Central States, Nebraska, and North Dakota. All of these are done or nearly done, as shown in the table below. The report writing is well along; publications of survey statistics are appearing regularly (see map).

Status of the Forest Survey December 31, 1956

State	: Field-	:	Proportion of job done		
	: work	:	Total	: Field	: Reports
	: completed	:	job	: inventory	:
	<u>Date</u>		<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
Initial survey:					
Illinois	1948		100	100	100
Indiana	1950		100	100	100
Iowa	1954		88	100	20
Kentucky	1949		100	100	100
Missouri	1947		100	100	100
Nebraska	1955		85	100	0
North Dakota	1954		100	100	100
Ohio	1952		100	100	100
Resurvey:					
Kansas	(1/)		13	25	0
Michigan	1956		76	100	31
Minnesota	1953		99	100	99
Wisconsin	(2/)		64	79	43

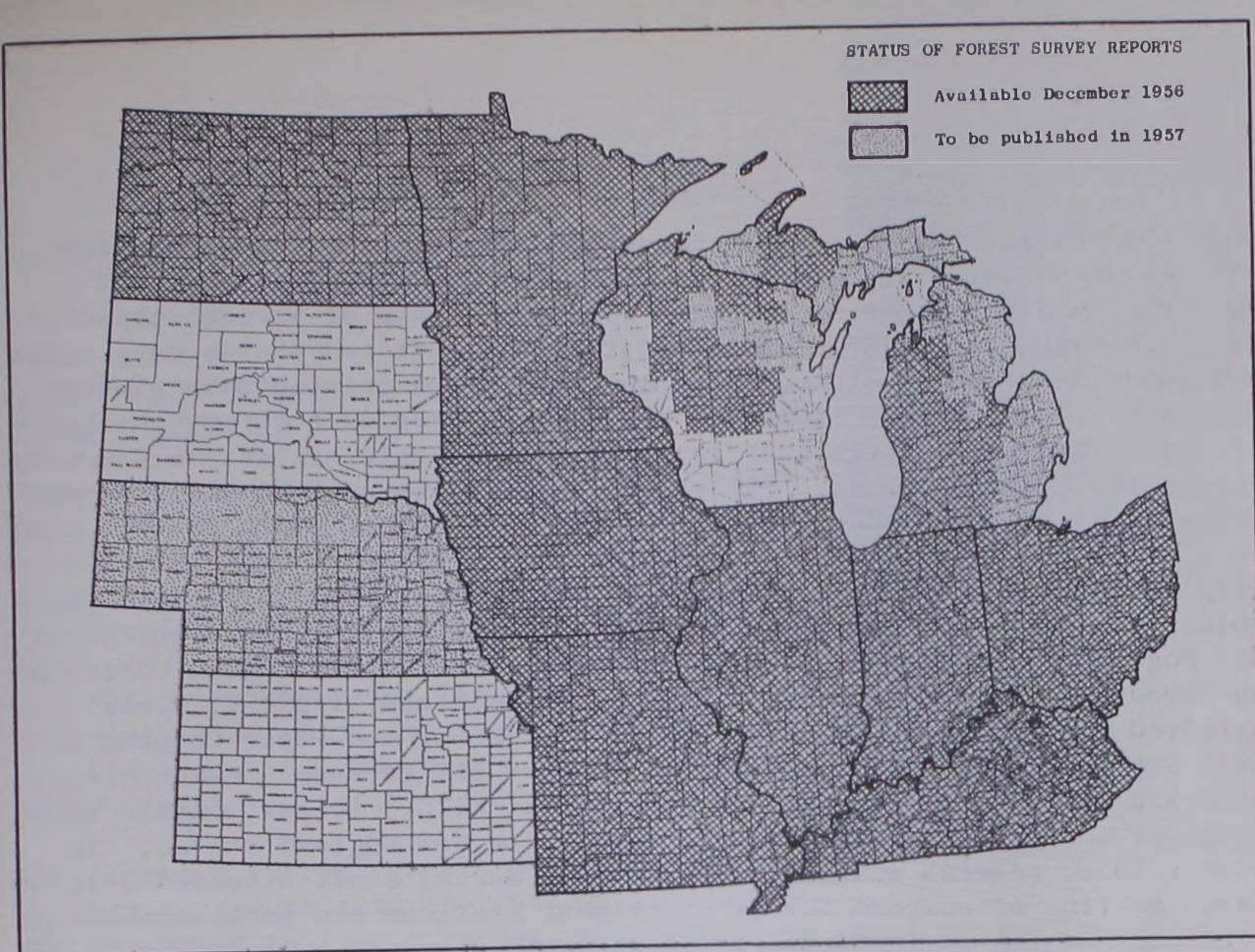
1/ Sample counties inventoried for Timber Resource Review.

2/ To be completed in 1957.

Future Survey

Work Planned

With the second round in the Lake States and the first round in the Central States coming to a close at about the same time, plans must be made for the next round. This time the surveys should be designed with three requirements high on the priority list: (1) Methods that will permit taking interim measurements at about 5-year intervals, (2) methods that will capitalize on the knowledge gained from past surveys, while at the same time allowing for complete new surveys at about 15-year intervals, and (3) procedures that will better integrate the results of surveys made by public and private cooperators on their own lands.



Previous surveys have been independent of each other. The results have shown the forest situation in an area at a particular time, but the direction and rate of change can only be approximated by comparing two sets of statistics. What we need now is a system that shows the changes due to growth, mortality, cutting, and regeneration more accurately and more often. For one thing, we need a system of permanent plots to be remeasured on a 5-year schedule.

A good start has been made in the Lake States toward building up a set of permanent plots on both private and public land. The next round of survey in the Central States will include this feature. Once the basic permanent plots are established, with provision for replacement and periodic additions to the total, the surveys will truly be continuous inventories, not unrelated jobs. They will show which species, types, densities, etc., are increasing and which are decreasing, and why.

The new emphasis on measuring change necessitates new techniques of survey. The Lake States Station and its cooperators in other public and private organizations are experimenting with new types of photography, sampling designs, cruising methods, and many other items that give promise of improving survey results. Some of these are described below.

Techniques Research
Emphasized

About 2 years ago the Iron Range Resources and Rehabilitation Commission, with help from the Mark Hurd Aerial Photo Company, the University of Minnesota, and this Station, began a series of tests of various types of aerial photography. Panchromatic and infrared modified photos were taken in summer and winter at three different scales and printed with varying contrasts. Considerable fieldwork was done to provide accuracy checks. This study brought out the superiority of large-scale winter panchromatic photos with light contrast. The study is being extended to include very large-scale (1:3,000) photography.

Early in the year conferences were held with cooperators to explore possible areas where changes in techniques or methods might be advantageous. Earl Rogers, a specialist in photogrammetry from the Washington Office of the Forest Service took part. Clarence D. Chase and Virgil E. Findell conferred with S. T. B. Losee of the Abitibi Power and Paper Company at Sault Ste. Marie, Ontario, Canada, to observe his methods. Later still, Chase and James T. Morgan went to Washington, D. C., to participate in a review of techniques research conducted in the New England States. In October 1956, several members of the Forest Survey staff attended a techniques meeting of eastern forest experiment stations and participated in a thorough review of the problems of survey design and methodology.

With this background, three studies of various techniques have been started. One is in Minnesota in cooperation with the Office of Iron Range Resources and Rehabilitation. It has to do with remapping 160-acre blocks and remeasuring sample plots established in 1946. Ability to identify and measure changes over a 10-year period is being tested.

A project in Michigan was designed to test a continuous inventory plan, based on systematically distributed 40-acre blocks and permanent sample plots. The original observations were made in 1949. Ability to determine timber cut by a stump tally is being investigated. Point sample (Bitterlich angle-count) plots are being compared with 1/5-acre plots. On the permanent plots, records are being kept on individual trees. Machine computing will be utilized to calculate changes. The Michigan Conservation Department and the American Box Board Company are cooperating with the Lake States Station on this project.

The third survey study is just getting under way in southern Wisconsin. This test features the use of aerial photographs for estimating gross volume and a proportional probability sampling scheme in which each plot represents equal proportions of forest land.

With the results of these tests and others which may be planned, the Station hopes to settle upon survey techniques which will be satisfactory for at least the next 10 years.

Michigan State forester paint-marking jack pine on a permanent plot in Lower Michigan.

Growth Estimates Will Be Improved

Recent forest survey growth predictions have been made by stand-projection methods. Diameter increment measurements on sample plots have been used to get gross growth factors for each major species. These have been discounted to allow for average mortality and deterioration. The resulting net factors are applied to stand and stock tables to get total net growth. The weak link in this procedure is the mortality estimate.

For checking current growth estimates and for projecting growth into the future, the survey men use empirical yield tables, a complete set of which has been derived from normal yield tables and previous survey data. Application of empirical yield tables requires the measurement of a number of variables, including density, stand age, and site index. Moreover, in actual application to survey material, they frequently must be used on stands of mixed composition and mixed ages.

Because of the weaknesses of both methods, the survey feels the need to devote considerable attention to possibilities for improving growth estimates.

The remeasurement of permanent plots appears to offer the best promise for obtaining good growth data. The difference in net volume between two inventories gives the net change. If records are kept for individual trees, it will be possible to identify the separate effects of growth, ingrowth, mortality, and cutting. After a series of remeasurements, much more will be known about mortality and the effects of stocking. Then perhaps some simpler short-cut methods can be derived for use on the survey.

Permanent plots are relatively expensive. Nevertheless, they seem to be the best known means for getting good net growth estimates.

New Pattern For Gauging Timber Cut

Pinpointing the geographic origin of logs and bolts and the size of trees cut by forest industries is one of the most difficult phases of the present timber-cut survey. Most of the current information is being obtained



through contacts with industry. This approach has met with varying degrees of success. Wood-using plants, as a rule, are able to show the origin of trucked wood with some degree of accuracy, but quantities shipped by rail must be determined by referring to railroad waybills showing the number of carloads of rough forest products loaded out from individual stations during the year. This is both difficult and time-consuming.

To overcome this obstacle, the Station is revising its methods to a 3-way approach to timber-cut estimation, with industry surveys, ownership cutting reports, and stump counts each having a definite part.

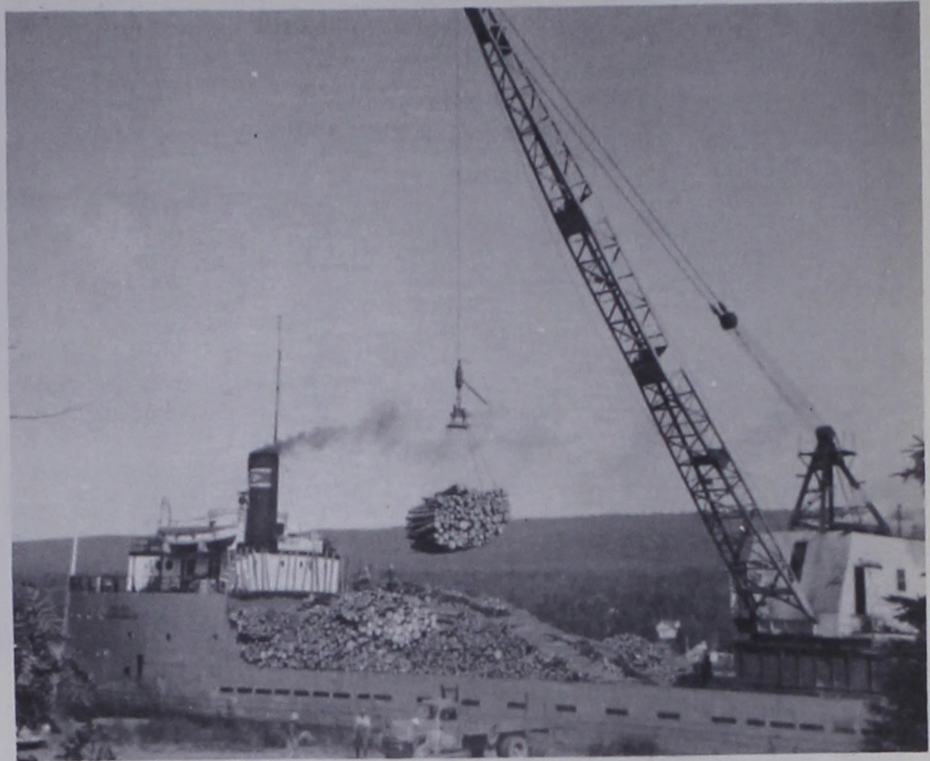
Industries will be contacted as in the past, but under the new system requests for information will be limited to log and bolt receipt figures. The Station plans to contact pulp and miscellaneous fiber mills every year; veneer, cooperage, excelsior, chemical mills, and miscellaneous wood-working plants biennially; other round and split products every fifth year; and lumber irregularly, depending on cooperation with the Bureau of the Census and forest survey collaborators.

The second phase, which will be integrated with the regular forest inventory work, consists of obtaining cutting information from permanent plots. When inventory plots are visited by the field crews, stump counts will be considered as much a part of the fieldwork as tallying trees. Stumps remaining from trees cut on 1/5-acre plots will be tallied by size and species and later converted to standing timber by applying volume figures based on measurements taken from felled trees on sample logging operations. These data will be used to distribute the Statewide timber drain (computed from industry reports) by districts, tree-size classes, timber types, and log grades.

The third phase will be aimed at obtaining timber-cutting reports from public landowners. Records are available from national, State, and county forests and other large public owners. Wide differences in allowable cut and actual timber-cut ratios by ownership warrant the collection of cutting reports by class of ownership.

The timber-cut plan is being revised on the premise that active cooperation will be extended by our collaborators as in the past. By working together it is possible to combine the most promising features of the production surveys, plot methods, and ownership records for determining more detailed and accurate timber-cut estimates.

Pulpwood being loaded on a lake freighter at Grand Marais, Minn.



Marketing Research

One important phase of the problem of utilizing more surplus low-grade timber in the Lake States is finding opportunities to use this material in existing industries or to show how they may be used in potential new industries. Studies with this aim may be called market research. The Station has initiated a number of independent studies of this kind. It has attempted to stimulate parallel studies by cooperative agencies, in some cases with active participation or financial aid, in some cases without. Coordination of the studies has been effected through activities of informal committees.

Station Has Initiated Four Studies

Pallet study.--The present consumption of hardwood pallets in the St. Paul-Minneapolis area and the outlook for future expansion have been the subject of two Technical Notes during the year. A full report has been prepared for publication early in 1957. John R. Warner and Ross Cowan are authors.



For convenience in handling and for full use of available storage area, materials are stacked on pallets. Note the pallets at varying levels in this picture. (See preceding page for pallet study.)

Wood use in automobile industry.--The pattern of wood consumption in one large company (Ford Motor Company) is being studied in great detail. The kinds, grades, and quantities of wood used in the manufacturing process, in the body of the car itself, and in the shipment of cars are being worked out on a per-car basis. Trends over a period of years are being studied. Charles Sutherland is project leader. He has been receiving excellent cooperation from the manufacturer as well as valuable help and guidance from faculty members of the University of Michigan.

Charcoal study.--A study of the domestic charcoal market in Wisconsin, initiated by the Station last year, has provided a fairly detailed market description, and some indication of consumption habits and trends. A preliminary report is being prepared by W. B. Lord and John Warner.

Spot checks indicated that more than 3,100 retail stores in Wisconsin sold charcoal during 1955. Sales for the year were estimated to be in excess of a pound per person and to total more than $4\frac{1}{2}$ million pounds. This volume converted to wood represents approximately 6,000 cords. This is somewhat more than was sold the previous year. The Station plans to make a more thorough sampling study of retailers in 1957. The outlook for domestic charcoal consumption in Wisconsin, together with an indication of consumer preferences on items such as charcoal form, bag size, and seasonal use, should be very helpful to those planning increased production for the local market. Although charcoal is but a small part of the total wood utilization picture, it offers one of the best potential outlets for wood waste.

Pulpwood study.--For 10 years the Station has been assembling information on woods used by the Lake States pulp and paper industry, including statistics on wood requirements, wood sources, and species trends. These, together with the most recent timber inventory data for the tributary area are being put together and analyzed. A report, "Wood Supply Problems of the Lake States Pulp and Paper Industry," is scheduled for publication early in 1957.

Most Active Cooperative Marketing Studies

Farm lumber consumption and use in Minnesota.--A survey of farm lumber consumption and use in an 8-county area of east central Minnesota was undertaken in 1955 in cooperation with the University of Minnesota Agricultural Experiment Station. It was conducted by Forest School personnel with financial assistance from the Lake States Station. A major objective was the development of sampling techniques and methods for estimating lumber consumption and use on farms.

Approximately 150 farm operators were interviewed to obtain information about lumber used on their farms. The figures have been analyzed and a report is being written by Dr. Ronald Beazley and Allen Lundgren.

Boxes and crates in southeastern Minnesota.--This study of wood use in boxes and crates, conducted by Prof. Ed Sullivan of the Minnesota Forest School with limited financial aid from the Station, was initiated in 1955 and is nearing completion.

General market survey of Twin Cities area.--The State Forester of Minnesota is eager to get a complete picture of the wood markets in the St. Paul-Minneapolis metropolitan area; this would be a helpful guide in the State's farm forestry program. He wants such information as who the buyers are, what the wood is used for, in what form it is purchased, how it is handled, and what species are used. He has directed his fieldmen to get this information. The Station has agreed to help him analyze the material collected.

Pulpwood market in Michigan.--Prof. Lee James of the Department of Forestry of Michigan State University has described the market for Michigan pulpwood in a report soon to be published as a bulletin of the Michigan Agricultural Experiment Station. This work has provided an insight into several phases of pulpwood marketing which deserve more detailed inquiry. Two of these phases probably will be investigated by D. N. Quinney as part of his Ph.D. program while on educational leave from the Station. They include (1) truck costs of pulpwood transport, considering routes and distances, and (2) the relation of pulpwood demand by species to the inventory of forest volume. The study will be confined to Michigan.

Plans for 1957

The most urgent need now is to prepare a problem analysis to guide future studies. Such an analysis will be concerned primarily with markets for and uses of low-grade surplus aspen, oak, ash, and other hardwood species. In addition to studies designed to quantify and describe market structure, thought will be directed toward methods which will relate the regional timber resource to marketing studies through correlating the availability of native wood species with the use of wood.

Other Economics Research

Forestry problems arising from the Soil Bank legislation, added to the already growing interest in the financial aspects of land use and timber production, have given impetus to the Station's program of economics research. Operations are still largely in the planning stage.

Soil Bank Studies Outlined

During the summer of 1956 the Station employed Prof. Ronald Beazley (University of Minnesota) to make a problem analysis covering forestry aspects of this program. His primary conclusions are:

1. Farm foresters, extension foresters, and other fieldworkers in wooded counties have urgent need for basic facts on costs and returns from forestry activities such as tree planting, cultural operations, and pest control. They need facts to present to landowners to help them decide what they want to do under the Soil Bank Program and in general farm management planning.
2. Useful time and cost records are available in a number of places, but there is need for someone to bring these together, evaluate them, reduce to a common denominator, and make available to fieldmen. The Station should take the lead. Cooperation should be sought at schools (both Forestry and Agricultural Economics) and elsewhere to make studies to fill gaps.
3. Outlining a forestry program on a farm involves careful budgeting of alternative combinations, a technique with which most foresters have had little experience. The Station should work with farm management economists on several case studies to familiarize themselves with procedures and to develop a pattern for larger scale work in the future.
4. There is need for better price and outlook information on forest products. This is not primarily a job for the Station, but the Station may supply technical help in setting up a sound sampling system for

fact collection. The Forest Service and Forestry Schools should continue to explore possibilities of forecasting future demand and prices.

5. Evaluating woodlands for some uses such as recreation, beauty, and water conservation in monetary terms is an almost impossible task but cannot be neglected. The Station should explore all possibilities.

Land Use Study Started in Southwest Wisconsin

The Mill Creek watershed in Richland County is one of several proposed for inclusion in the program under the Small Watersheds Act (Pub. Law 566). An association has been formed. Federal and State agencies have approved the application. A planning team of Soil Conservation Service technicians has drawn up a conservation plan in which they propose that approximately 30 percent of the area be devoted to conservation uses, specifically:

Woodland protection (steep slopes)	13.2 percent
Wildlife area improvement	1.2 "
Tree planting	1.0 "
Pasture planting	11.5 "
Grassland farming	2.6 "
	<u>29.5 percent</u>

Public agencies have been working toward such a program for a number of years. Among 321 farmers in the Mill Creek watershed, 179 are SCS co-operators. About one-half are receiving Agricultural Conservation Program payments. To date, however, only 6 percent of the recommended program has been accomplished. The main obstacles appear to be economic. Some operators with small farms, poor soil, and low farm income seem forced to exploit the land to make a living.

A Station project, in cooperation with the Department of Agricultural Economics, University of Wisconsin, aims to explore by means of case studies the principal obstacles to putting the recommended forestry practices into effect. For example: (1) What are the costs to the farmer? (2) What returns may be expected and when? (3) How will the recommended use fit into his overall farm organization pattern? Land, labor, capital, and income requirements must be considered. (4) What is the effect of current public programs? (5) What lines of possible future action seem promising? One case will be given thorough study during the current fiscal year; others will be added later. Wm. B. Lord is project leader.

Forestry Cost Studies Planned

On the Cutfoot Experimental Forest is a management unit supervised by the Headwaters Research Center, Grand Rapids, Minn. It is handled much as a private owner might manage a tract of good timberland. Over a period of years data have been accumulated on costs such as land investment, taxes,

improvements, various cultural operations, and logging. To date the foresters in charge of the project have not had the opportunity to analyze the records and draw conclusions. Last August Allen Lundgren was assigned to the Center with the primary responsibility of analyzing the financial aspects of the forest management project. He helps also with other projects which have economic phases.

After available records have been analyzed, attention will be given to obtaining other needed input-output records both for farm forestry and commercial forestry and to their application to practical problems both within the Center and elsewhere.

F O R E S T P R O D U C T S

U T I L I Z A T I O N R E S E A R C H

by Arlie W. Toole, Division Chief

Economists and producers generally agree that the demand for wood as a basic raw material will increase in the future if supplies of wood of suitable quality continue to be available at economic levels. Research has shown that intensive forest management will promote the greatest production of high-quality timber growth at minimum cost. But greatly expanded uses for low-quality hardwoods are needed to create conditions favorable for more intensive silviculture in the Lake States. Also, the economics of use must be favorable, and the benefits of applying intensive silviculture and management to forest land must be demonstrable by research findings.

In many areas of the Lake States the best forest management requires the establishment of coniferous species on millions of acres of forest land (over 4 million acres in Minnesota alone) now taken over by brush, poorly stocked aspen, and inferior hardwoods. To create favorable site and economic conditions for coniferous reestablishment, efficient low-cost methods of harvesting and processing the present cover must be developed. Considering the economic importance of a plentiful supply of coniferous species for pulp and paper production in the region, adequate provision should be made for this kind of research.

Major studies now under way in forest products utilization research are discussed briefly in this report, together with any significant findings that can be outlined at this time. The 1955 Annual Report provided background information and cooperative relationships established in conducting this research. Much of this information is applicable to the present discussion.

Service Life Records of Treated Wood

Cooperation of this Station and the School of Forestry and other branches of the University of Minnesota continued to expand the work in fencing studies and related investigations of preservatively treated wood products and native lumber for farm use.

In a cooperative project at the Rosemount Research Center, University of Minnesota, two lots of northern white-cedar posts that had been in 120 rods of experimental fence for 8 years were examined during 1956 for variables of treatment and preservative. One lot of 80 posts, which had been given a quick butt dip in hot creosote, was found to be totally unusable, but the lot which had been given a 48-hour butt cold soak in a 5-percent penta solution was entirely reusable. Some of the poorly preserved posts had been damaged by a fence row fire 2 years previously, but none of the sound posts was injured, indicating that fire damage was due to the presence of decay rather than the type of preservative used.

Power-Driven Fence Post Studies

Initial tests on power-driven posts were completed at Rosemount Research Center during the summer. Two hundred commercially pressure-treated (creosote), 3-inch round jack pine posts were driven in 4 lots of 50 posts each to test variables of pointed and blunt ends driven small end and large end down. Withdrawal resistance of these posts will be carried out to complete this test.

The pointed posts required up to 20 percent less power for driving to the 24-inch depth than the blunt posts; also, all the pointed posts were tight in the soil after driving, but some of the blunt posts were loose. The power required for driving a post pointed at the small end was not significantly different from that required to drive one pointed at the large end. Blunt posts also showed no significant differences between driving the large versus the small end.

This test was carried on cooperatively with the Agricultural Engineering Department, University of Minnesota, and the Wheeler Lumber Bridge and Supply Company.

Use of Treated Wood on the Farm

A second insulated and ventilated pole farm structure, replicating many features of the building reported in 1955, was planned this year by interested divisions of the University of Minnesota for erection at Rosemount Research Center in 1957. Three types of poles will be used: (1) Full-length round, (2) squared above ground line to 5-5/8 by 5-5/8 inches, and (3) full-length squared timbers of this size. Preservative treatments

include pressure penta, pressure creosote, vacuum penta, and vacuum penta with penta grease at ground line. Several types of side-wall construction and treatment are included in the plan.

Part of the lumber for this structure was produced from the Cloquet Experimental Forest and treated there in the experimental vacuum treating plant. Including this and other experimental runs, the experimental treating plant was operated 33 times during 1956.

Detailed plans for an inexpensive, portable, cold-soak, farm treating tank were issued as Technical Note 454. This tank will accommodate material up to 16 feet long and 12 inches wide. It is built of low-cost sheet metal supported by a well-designed wood frame.

Seasoning of Wood and Roundwood Products

Many of the uses for which wood and timber products are suitable can best be determined by knowledge of the physical and engineering properties of each species. Work in wood moisture relationships is being carried on cooperatively to determine seasonal moisture contents in standing and felled trees and stacked arrangements.

Fieldwork is complete and data analysis nearly complete on studies of seasonal variation in moisture content of standing jack pine throughout the year and the time and rate of moisture content change in trembling aspen and jack pine during the spring and fall. An interesting part of the project has been the development of a machine for rapidly removing from standing trees wood moisture samples larger than those obtainable with an increment borer. A modified commercial plug cutter was attached to a "Little Beaver" backpack gasoline engine and successfully used in obtaining the large number of moisture content samples required in the experiment. This study has been carried on cooperatively with graduate students of the School of Forestry, University of Minnesota, under faculty supervision.

Kiln-Drying Schedules for Domestic Woods

Wood-moisture relationships are particularly important in the development and manufacture of products that can be produced with few intermediate steps from billets, bolts, or logs. Practical seasoning techniques for thick dimension stock would encourage production of this item from suitable bolts, which could be obtained in forest improvement cuts in large volume. An initial study to determine the effects of several variables in kiln-drying thick dimension stock has been completed, and a report covering the results of this test is being prepared. Additional seasoning tests will be made in evaluating variables of sawing bolt material on the bolter saw. This work is being carried on cooperatively with graduate students in the Wood Technology Department, University of Michigan, under faculty supervision.

Relation of Cultural Practices to Tree Quality Development

A joint management-utilization study was started on the Argonne Experimental Forest, Wis., to develop methods of cutting northern hardwood pole stands to obtain the maximum growth and quality in a stand managed for high-grade sawlog trees. This study will provide information on tree defects and their relationship to stand conditions, rate of growth, and the development of high-quality wood. The quality of the standing pole trees will be judged on the basis of visible external characteristics, and as the pole stands are cut to various stocking levels the effect of stand density upon growth and tree quality will be recorded.

Diagramming trees to locate defects and degrading factor in quality and growing stock level study in hardwood pole stand, Argonne Experimental Forest, Wis.

Tree Quality in Northern Hardwoods

In few timber types are the attributes of quality more important or more difficult to determine than in the northern hardwood type. A field study to develop a system for evaluating the quality of northern hardwoods was conducted at the Ford Forestry Center Research Sawmill, Alberta, Mich., in cooperation with the Michigan College of Mining and Technology and the Forest Products Laboratory. Basic information was sought on the relationship between visible characteristics in the tree and the quality of the wood.



Mature sugar maple trees, ranging from 11 to 34 inches in diameter, were cut from a northern hardwood stand on the Upper Peninsula Experimental Forest. Defect data were recorded prior to felling, and detailed defect diagrams were made after the trees were bucked into logs. The logs were sawed into 1-inch flitches which were then photographed in color. The photographs are being analyzed to develop a reliable measure of wood quality. The major premise is that tree quality can be measured by the amount and proportion of clear wood in a tree; that is, as these increase, the value of the tree increases.

Cost of Skidding Logging Residue

Studies on evaluation, logging, and processing of hardwood logging residues are being conducted cooperatively with the Michigan College of Mining and Technology.

One phase of this investigation concerned the problems and costs of moving the residue material from where it lay in the woods to a landing on an all-weather truck road. An objective was to do this at a cost that would be competitive with other sources of raw material for the wood distillation industry. Skidding was done in two stages. A small rubber-tired tractor was used to gather the scattered material and deposit it on a logging tractor road. A larger capacity tractor then skidded larger loads to the truck landing. This division of labor resulted in improved speed and lower costs; skidding the material from woods site to truck landing cost \$6.90 per ton mile. With the residue material gathered at truck landings, the next study will investigate some stage of initial processing to get it into a usable or transportable form at a minimum cost.

Logging Damage in Selectively Cut Stands

In cooperation with the Ahonen Lumber Co. of Ironwood, Mich., the Upper Peninsula Research Center continued a study on the damage to northern hardwoods after partial cutting. This study indicates that tree-length skidding with a large tractor and arch injures more residual trees (27.3 percent) than either tree-length skidding (13.7 percent) or ground skidding of logs (8.5 percent) with smaller equipment. Selected specimens of injured trees will be dissected periodically to determine the resulting degrade and loss.

Charcoal Production in Small Kilns

The Station continued its research on charcoal production in small kilns. Major emphasis was given to improving kiln designs and studying the carbonization process. Two experimental kilns were constructed on the Argonne Experimental Forest to test new designs and develop operating techniques. One new design feature that proved particularly valuable was double-wall construction with an intervening space for insulation and sand. This shortened carbonization time by conserving heat, resulted in more uniform kiln temperatures, and provided a better air seal during cooling.

Preliminary results indicate that two commonly available materials, cinder-concrete block and corrugated sheet metal, are both satisfactory provided kiln temperatures are not allowed to exceed 1000° F. A desirable range of temperature for producing good domestic charcoal appears to be from about 800° to 900°.

Three-cord experimental charcoal kilns featuring double-wall design with interior test walls of (1) corrugated 18-gage sheet metal and (2) cinder-concrete blocks, Argonne Experimental Forest, Wis.

A test was also made with a supplemental source of heat (oil burner) for carbonization. Preliminary results indicate cycle time may be

reduced and charcoal yield improved without increasing production costs.

Continuance of a cooperative study with the Cliffs-Dow Chemical Co. on the mechanics and economics of cordwood handling and charcoal production in small field kilns has been made possible on the Upper Peninsula Experimental Forest by the construction of a new 7-cord kiln designed by the Forest Products Laboratory. Design improvements include double masonry walls with an 8-inch sand column between to function as an airtight barrier and to provide greater wall mass for better heat retention. The inner masonry wall is formed of bituminous coal cinder blocks of a special heat resistant formulation. The outer wall is made of ordinary cement-gravel blocks. The new design provides for maximum isolation of metal components from areas of high temperature; that is, clearance for expansion. Total material costs, excluding labor, amounted to \$1,200.

The successful completion of 1 curing burn and 2 production burns indicates that this new kiln will be very responsive to control, and that it can probably be operated on a 6- or 7-day cycle. Tests will be made of as many combinations and variations of wood and charcoal handling equipment and techniques as possible. Time studies will be made to determine the most efficient and least costly of these.

Side view of new 7-cord masonry experimental charcoal kiln on the Upper Peninsula Experimental Forest. Double-wall design with dry sand fill between a cinder-concrete block interior and ordinary concrete block exterior.



Plans
for 1957

An immediate objective of forest products utilization research will be to develop as soon as possible a program of research in timber harvesting and processing. The contribution which a well-integrated research program in this field can make to economic progress in the timbered areas of the Lake States is recognized. Studies now in progress will be continued and expanded as opportunity arises, but present studies constitute a full workload for technical personnel now available. Expansion will, of necessity, require additional resources which can be allocated to personnel and project working allotments. Successful research develops new opportunities for further research. This is as it should be, for only by a process of continuing to explore new fields as they develop can progress be maintained.

F O R E S T M A N A G E M E N T

by R. D. McCulley, Division Chief

Research in Forest Management continued to move forward on a broad front in 1956, supplying information fundamental to the timber-growing programs of landowners and land managers throughout the Lake States region. The bulletins issued on pruning and selection of superior trees were mentioned earlier. In addition, growth requirements, ranges of distribution, and environmental associations of 13 tree species native to the region were summarized in rough draft. These summaries now are being reviewed by technicians in other forest research agencies to assure completeness and accuracy. Following preliminary publication by the Station, they will be included in a silvics manual containing similar material for about 130 tree species nationwide.

Work has begun in North Dakota under the direction of Paul E. Slabaugh, a staff member with long experience in the planting of forest trees in the Plains. The needs of Plains forestry have been reviewed with the foresters of North Dakota as the first step in renewing research in that area. Better methods of establishing conifers, selection of criteria for pinpointing the species that should be planted on different sites, breeding of improved varieties, rehabilitation of decadent plantings, and utilization of the products of natural woodlands were noted as problems requiring solution.

Facilities for intensive research have been improved through completion of laboratory and greenhouse space at the Hugo Sauer Nursery near Rhineland, Wis. The tree improvement research of the Station thus has been strengthened materially. However, only a start has been made in providing the type of working space that will be needed in the more fundamental research envisioned in the years immediately ahead.

Those are a few examples of work under way in Forest Management. In the following sections are additional items of current interest and notes on plans for the coming year.

Genetics Research

Increasing population and multiplying industrial activity will demand greater wood production from forest land of the Lake States and the nation. Demands that cannot be met by bringing stands up to full stocking can be attained only by developing and using trees that are inherently better in quality and productiveness than those now available. The major aim of the genetics research of the Station is to determine the means of reaching this goal.

The spruces are among the most valuable pulpwood species of the region and are in short supply. For these reasons (and the opportunity to improve the species because of its genetic variation), the Station's initial work in tree improvement has concentrated on white spruce, a species of wide range and great genetic variation.

Flowering in White Spruce

Fundamental information on the process of flower formation and the phenology of flowering in white spruce is necessary for successful application of controlled pollination work.

Beginning in the spring of 1956, flower buds of spruce were collected at regular intervals and observations were recorded as to color, appearance, and general development at the time of collection. This material has been preserved and will be examined in detail under the microscope to shed light on these two questions: (1) When are flower primordia formed, and (2) how soon after a given stage of development will the flowers be ready for pollination?

Increasing Success in Grafting

A study was started in the fall of 1955 to develop fall grafting methods so that both cones and scions of desirable genetic qualities can be economically collected at the same time. Fresh scions of 35-year-old white spruce and Norway spruce were grafted on potted white, Norway, and black spruce seedlings. A portion of the stock had been exposed to various combinations of temperatures and length of day. After the grafts were made, plants of each group were again exposed to short-day and long-day treatments. Results after 8 months indicate that long-day treatment after grafting increased the take to 48 percent compared to 22 percent for the short-day treatment. These data, plus those from various combinations of temperature and length of photoperiod, show that an actively growing

cambium at the time of grafting materially increases the success. Black spruce proved to be unsatisfactory as a stock plant. Covering the grafts with mounds of sphagnum or moist sphagnum within a polyethylene bag improved the results.

This study was repeated on a larger and more comprehensive scale in September 1956, using a greater variety of methods for holding the scion to the stock.

Exploratory Spruce Pollinations

Tree breeding depends heavily on the use of controlled pollinations, so exploratory pollinations were made during the spring of 1956. White spruce pollen was applied to white spruce flowers over a period of several days in an attempt to determine the time of greatest receptivity to pollination. In another series of tests, pollen of Picea abies, P. asperata, P. montigena, P. koyamai, P. pungens, and P. jezoensis were applied to white spruce flowers; most of these same pollens, plus that of white spruce, were applied to black spruce.



Controlled pollination of black spruce, Nicolet National Forest, Wis. The cone flowers have previously been covered by sausage casing and kraft bags. When the cone flowers reach the receptive stage, the kraft bag is removed, a hole punctured in the sausage casing, and the desired pollen introduced with a syringe or comparable instrument. Then the hole in the casing is sealed and the kraft bag again tied over the casing. Later the bags are removed and the new cones allowed to develop normally.

These tests also included special hormone treatments to increase receptivity of the flowers, insecticide treatments to control injurious insects, and investigations of different types of bagging material.

The cones have been collected from these pollinations, and tests will be undertaken to determine seed viability and the character of the seedlings.

Length of Growing Season and Genetic Development

Cone collections were made in several white spruce stands within a radius of 35 miles of Marquette, Mich. The selected locations provided a range in growing season of 80 to 140 days. Such a wide range in such a small geographic area furnishes an unusual opportunity to test under natural conditions the variation in progeny and parents arising from difference in length of growing season.

Seed Source Studies in Jack and Eastern White Pines

Second-year growth and mortality in the regional jack pine seed source study do not disclose any distinct pattern of differences between the 29 seed sources planted in 17 different localities. Some plantings have been injured by the tortoise scale (Toumeyella numismaticum) and the red-headed pine sawfly (Neodiprion lecontei), but neither pest has been selective.

Additional seed collections were obtained in the Lake States for the local extension of the interregional white pine seed source study in which the Northeastern, Southeastern, Central States, and Lake States Stations, as well as the Ontario Department of Lands and Forests, are cooperating. However, a crop failure in Lower Michigan precluded collecting there, one of the basic sources to be used by all cooperators. Testing of the seed of 12 sources that were obtained last year showed a considerable range in both germination percent and degree of dormancy.

Hybrid Poplar Clonal Tests

Fifth-year examination of hybrid poplar clonal tests installed by the American Box Board Company in Wexford County, Mich., was made in October 1956. Only 2 of the 50 clones tested have attained an average height of over 10 feet. A few individual trees within these better growing clones have reached a height of 20 feet. Mortality has been exceptionally heavy and a majority of the remaining trees are of low vigor. Damage from insects and animals has been relatively high. At this time none of the clones being tested shows promising ability to compete in survival and growth with natural aspen suckers.

Tree Improvement Problems in North Dakota

In connection with the reactivation of Station research in North Dakota, a survey was made of forest tree improvement problems in the State. Improvement of tree-planting results in the Plains long has been sought through use of species of superior drought resistance. Significant progress has been made in this direction in the past, but future gains may be even greater.

Plantation Management

Among the forest regions of the United States, the Lake States are first in planted acreage. In 1952 this region had 1.4 million acres of successful plantations, 27 percent of the national total. Some of these plantings now contain merchantable material; many others soon will. Management methods for these plantations must be developed to gain the maximum benefits from the considerable investments that have gone into their establishment and protection.

Thinning Young White Spruce Plantations

The proper spacing of white spruce plantations and their rate of growth are points of interest to Lake States foresters because increasing amounts of this species are being planted in the region.

In late 1948 the forestry staff of the Menominee Indian Reservation worked with the Station in installation of a series of 12 plots in a 23-year-old plantation originally spaced 2x4 feet and averaging around 3,830 trees per acre. Thinnings were made to leave residual stands per acre of 750, 1,000, 1,250, 1,500, and 1,750 trees.

In 1955, 6 years after thinning, measurements of the largest 350 trees per acre show almost as much growth for unthinned trees as thinned ones. Indications from this short period are that white spruce, even in extremely dense stands, will express dominance early and produce satisfactory growth.

Snow Damage to Red Pine Plantations

An appraisal of present and potential red pine utility pole supplies in Lower Michigan showed that sweep was one of the major pole defects in red pine stands. An examination of a number of red pine plantations in 1956 disclosed that heavy snow in sapling stands is the most serious single cause of this type of defect. Heavy snows occur in this area almost every year. Less important causes are wind damage, poor planting practices, or growth response to overhead shade.

Plantations overtopped by hardwoods were most severely damaged. The trees in such plantations had asymmetrical crowns, which made them extremely susceptible to bending when burdened with snow. In plantations free from overhead cover, severe bending was most pronounced in small spindly trees, again especially those with asymmetrical crowns. In older plantations slender, intermediate or suppressed trees and small trees on the edges of chance openings suffered most severely.

A reexamination of the trees in the spring indicated that permanent damage usually occurred only when severe bending extended down through the upper half of the crown. When the bending was confined to the last 2 years' growth, practically all the trees recovered.

Red pine plantations overtopped by hardwoods were most seriously damaged by snow--Mio, Mich.



Growth of a Red Pine Plantation

In 1937 a red pine plantation was established in northern Minnesota on a site prepared by cutting of hardwoods and disking. Despite this complete ground preparation, the stand required weeding during the 3 years following planting. In 1951 the plantation was thinned from 2,420 trees to 1,500 trees per acre to yield 1.1 cords of post and pulpwood material to a 3-inch top diameter and $4\frac{1}{2}$ cords of stake and fuelwood to a 2-inch top diameter. A second thinning in the spring of 1956 further reduced the stand to 750 trees per acre, with a harvest of nearly 10 cords of pulpwood and post material and another $4\frac{1}{2}$ cords of smaller wood. The residual stand, which is made up of the best trees, has a volume of about 15 cords of pulpwood and post material.

Thus, in the spring of 1956, after 22 growing seasons from seed, this red pine plantation has grown more than 25 cords of wood with a 3-inch top diameter and larger. An additional 9 cords of stake and fuelwood material have been harvested.

Red pine plantation at 22 years from seed. Post and pulpwood products harvested are in the background. The yield per acre from 1.4 acres in 1956 was 9.8 cords of post and pulpwood material and 4.5 cords of topwood.



Chemical Herbicides in Forest Management

Frequent requests were received during the year for information on the use of chemical herbicides in forestry operations. These indicate the importance assumed by this new tool for vegetation management. Herbicide research figured prominently in the Division's research program.

Chemical Brush Control Meeting

Another in the series of brush control meetings was held this year at Cadillac, Mich., September 11-13, under the sponsorship of the Station, the Michigan Department of Conservation, and the Dow Chemical Company. Three fields of chemical brush control--game habitat management, forest management, and utility right-of-way maintenance--were discussed, and tests viewed in the field.

The field trips included areas treated with aerial sprays to improve game habitat by top-killing scrub aspen, thus encouraging root suckering; to improve waterfowl habitat by controlling aquatic vegetation; and to release pine from scrub oak and aspen overstories. Areas treated with ground equipment showed pine release and control of brush on utility rights-of-way.

Ground Preparation by Aerial Spraying

Evidence of the value of aerial spraying as a method of preparing brushy sites for planting is furnished by the development of a 20-acre red pine-white spruce plantation on the Superior National Forest. This very brushy area was sprayed with 2 pounds of a 2,4-D and 2,4,5-T mixture in 4 gallons of solution per acre in July 1954 and planted the following spring. At the end of the second growing season, only 13 percent of the pine and 25 percent of the spruce needed release from competing vegetation on the sprayed plot compared to 73 and 62 percent respectively on adjacent unsprayed land. Judging from the slow recovery of the brush, no further attention need be given the sprayed planting for at least 2 more years. This compares favorably with brush competition on similar sites following disking. The less expensive aerial spraying thus offers great promise as a substitute for disking in the pre-release of brushy upland planting sites.

Minimum Amount of Herbicides to Use in Aerial Spraying

Aerial spraying of herbicides to control brush and release plantations has excited the imagination of foresters, for it is a method of doing an otherwise expensive and time-consuming job quickly and inexpensively. Although generally effective methods can be prescribed for many areas, research should be continued to determine the minimum volume of chemical needed to obtain satisfactory release. Two experiments were installed last year to answer this problem in different types of cover.

In cooperation with the Minnesota Office of Iron Range Resources and Rehabilitation and the Superior National Forest, special spraying cages and equipment were used to install 580 small test plots of simulated aerial spraying of hazel and mountain maple. At regular intervals during the growing season, tests of 3 concentrations and 3 volumes of 3 herbicides in water carrier were made on these plots. Preliminary first-growing-season results will be tallied next year.

In Lower Michigan a test was installed to determine the minimum application of 2,4,5-T that will result in satisfactory control of scrub oak overstory in pine release operations. One-quarter pound of acid equivalent per acre in both fuel oil and water carriers and $\frac{1}{2}$ pound in water were applied from the air. Preliminary observations at the end of the growing season, several months after application, indicate that $\frac{1}{2}$ pound per acre controlled the oak as well as did 1 pound of brushkiller (a mixture of 2,4-D and 2,4,5-T) used in regular control applications in an adjacent plantation. Results of the $\frac{1}{4}$ -pound applications are inconclusive as yet.

Control of Green Alder by Basal Spraying

Aerial spraying is an effective method of controlling woody plants on large areas, but it cannot be used on small irregular tracts or during the dormant season. Basal spraying is one method of treatment that can be used during the dormant season, but it has often proved expensive because of the large quantity of material that has to be employed.

In an effort to reduce the cost of basal dormant spraying, a series of tests was run in Minnesota using various concentrations of 2,4,5-T in oil to treat clumps of green alder in the spring of 1955 before the leaves were out. Measurements at the end of the second growing season indicate that basal sprays containing about a pound acid equivalent of 2,4,5-T per 100 gallons of diesel oil will kill about 80 to 90 percent of the stems. Stronger solutions will result in more complete kill of the brush, but, for many forestry purposes, kill obtained with a 1-pound solution will be satisfactory and more economical.

2,4-D Amine Salt in Frill Girdles to Control Oak

In 1954 and 1955, tests using small volumes of various herbicides in undiluted formulations showed that the amine salt of 2,4-D gave the best kill in frill girdles. Concentrated solutions in small volumes save considerable oil and labor over the more dilute solutions customarily applied; in addition, the amine salt of the herbicide is cheaper than the ester.

Additional experiments were tried in 1956 to determine the minimum amount of the salt that could be used to give good control. The earlier tests showed that as little as $\frac{1}{2}$ ml. of undiluted formulation (4 pounds acid equivalent per gallon) per inch of diameter in frill girdles was effective,

but that less than that volume was impractical under field conditions. Consequently, the amount of solution was limited to $\frac{1}{2}$ and 1 ml. per inch of tree diameter, but the concentrations were varied, using water as a diluent. Concentrations used were undiluted and 75-, 50-, and 25-percent solutions. Equal numbers of red and white oaks ranging from 6 to 12 inches in diameter were treated in the dormant season in early April and immediately after completion of full leaf development in late June.

By September 1956 all of the treated red oak were top-killed regardless of treatment. All applications except one also top-killed about 85 percent of the white oak. The lightest application, however--the 25-percent concentration at the rate of $\frac{1}{2}$ ml. per inch of diameter--top-killed only one-third of the white oak in April and one-half in June. One-half of the red oaks and three-fourths of the white oaks killed in the April test sprouted with no difference because of treatment. None of the red oaks and only 10 percent of the white oaks killed in the June applications sprouted regardless of the amount of herbicide applied.

At least one more growing season will be needed before a final evaluation of this method can be made, but the possibilities of reducing the cost of chemical frill girdling look very promising.

Chemical Debarking on Oak and Aspen

Preliminary results of chemical debarking tests on northern pin oak and aspen in Lower Michigan show that the alkanolamine salt of 2,4-D at 4 pounds acid equivalent per gallon compares favorably with a 40-percent solution of sodium arsenite when applied in a frill girdle.

Treatments with applications of 4 to 5 ml. of the solutions to the axe girdle were begun on May 24, 1956, and repeated at 7- to 14-day intervals throughout the sap-peeling season. Both chemicals gave effective top-kill throughout the test period. Examination of the trees in October for the bark loosening effects showed that the May 24 and June 1 applications of the 2,4-D solution gave results equal to the arsenite, but later treatment resulted in more difficulty in peeling. Sodium arsenite was equally effective throughout the peeling season. The final results will be judged in the spring of 1957 after the trees have been exposed to the bark-loosening effects of the elements.

Natural Pine

Although the acreage of natural stands of pine has been drastically reduced from that which greeted the first settlers of the region, the area that remains represents a forest resource of considerable value. Growth potential is high, the products are in good demand for a variety of uses, and markets promise to be good in view of the nationwide shortage of coniferous woods.

Growth of a Young Managed Red Pine Stand

A red pine stand, now about 50 years old, was released and thinned during the Civilian Conservation Corps program in the late 1930's. In 1947 it was thinned for posts and pulpwood; 3.7 cords per acre were removed, and a residual stand of growing stock of about 120 square feet of basal area was left. In terms of cordwood, the annual growth for the 9 years has been 2.2 cords of wood per acre to a 3-inch top diameter. Nearly all of this growth is on residual trees since ingrowth has been negligible.

Thinning of Young Sapling Jack Pine by Mechanical Means

In 1945 the Station cooperated with the Mosinee Paper Mills Company in trials of mechanical thinning in overdense, 9-year-old jack pine. The purpose was to determine the effect of thinning with an Athens disk and crawler tractor on the growth rate of the remaining trees and possible reduction of mortality by snow and ice bending and breaking.

The 10-year remeasurement of this study indicates that removal of approximately 60 percent of the stand by disking has resulted in a definite growth increase on the remaining trees (about 5,000 trees per acre were left). Average d.b.h. of the largest 250 trees per acre on the untreated area now is 2.9 inches, while those from the thinned area average 3.5 inches. In addition, these trees are more sturdy and therefore less susceptible to snow and ice damage. Although beneficial, the treatment does not permit any selectivity in its application. Some poor trees are left to grow and some good ones are necessarily destroyed. The best opportunity for such a thinning system lies in very young overdense stands that have come in following fire.

Swamp Conifers

The swamp forests, located mainly in the northern portions of the Lake States, provide a considerable portion of the locally obtained coniferous woods used by the large pulp industry of the area. Generally the trees of the swamps are small, but occasionally one will make sawtimber. Northern white-cedar also provides post and pole material. The value of the swamps for protection of and food for wildlife is well known. Research in swamp stands has long been an important part of the program in forest management.

Seedbed Conditions Affect Black Spruce Reproduction

Type of seedbed appears to be one of the basic factors through which cutting methods and slash treatment exert an influence on the success of natural regeneration of black spruce. Counts of reproduction in a slash-disposal study on clear-cut strips indicate that seedling establishment

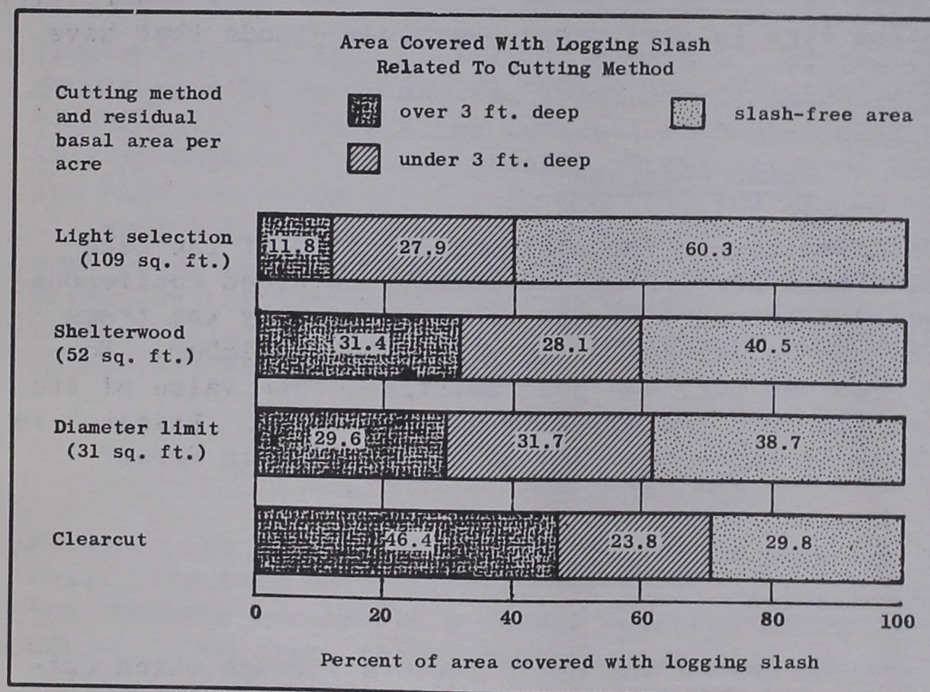
varies widely by natural seedbed types. Slash was burned in windrows on a portion of the area, thrown off the strips on another, and left in windrows on a third section of the strips. A tally of reproduction by seedbed classes indicates that one of the major effects of slash treatment is to influence the relative proportion of various seedbeds available. The sphagnum mosses and burned duff were good seedbeds; the "feather mosses" (*Hypnaceae*), the *Dicranum* mosses, and raw litter were poor. For all slash treatments combined, sphagnum seedbeds covered 39 percent of the area but accounted for 91 percent of the spruce seedlings. In contrast, raw litter covered an average of 14 percent of the area but bore no seedlings at all. Where no slash disposal was practiced, raw litter still made up 28 percent of the seedbed area 3 years after cutting. Only 3 percent of the seedbed was classed as raw litter where slash had been thrown off the strips, and only 10 percent was so classed where the slash had been burned.

Effect of Cutting Methods on Slash in Mixed Coniferous Swamps

Slash accumulations were studied in two mixed coniferous swamps in northern Michigan after cutting for regeneration had been completed by clear-cutting, diameter-limit, shelterwood, and light-selection methods.

As would be expected, the amount of slash was strongly correlated with the volume cut (see figure). For example, clear cutting left only 30 percent of the area slash free. Depth of slash, which has a strong bearing on reproduction, also was considerably greater on the clear-cut area than on the lighter intensities of cut. The distribution of slash varied with the intensity of cut. For example, only 12 percent of the milacre plots

in the light selection area were completely covered with slash compared to 46 percent in the clear-cut area.



Dense slash has a detrimental effect on both advanced reproduction and establishment of new seedlings in these mixed conifer swamps.

White-Cedar Management

The northern white-cedar swamp type in Wisconsin is a high-value type in which intensive measures to encourage faster growth and to produce high-quality products may be feasible.

In 1947 the Station, in cooperation with the Wisconsin Conservation Department, established a comprehensive thinning study in this type to test levels of stocking ranging from 90 to 240 square feet of basal area. The timber on the study area was mainly white-cedar with some balsam fir and black spruce in mixtures. The 60- to 100-year-old trees averaged about 5 inches in diameter and 30 feet in height at time of thinning. Analysis of height and age information showed the site to be about average for northern white-cedar.

Remeasurement of this study in 1956 after 10 growing seasons revealed that plots with a residual growing stock of from 110 to 135 square feet of basal area grew the best in terms of basal area. Individual white-cedar trees grew more than 2 inches in diameter in 10 years. Additional details will be published shortly.

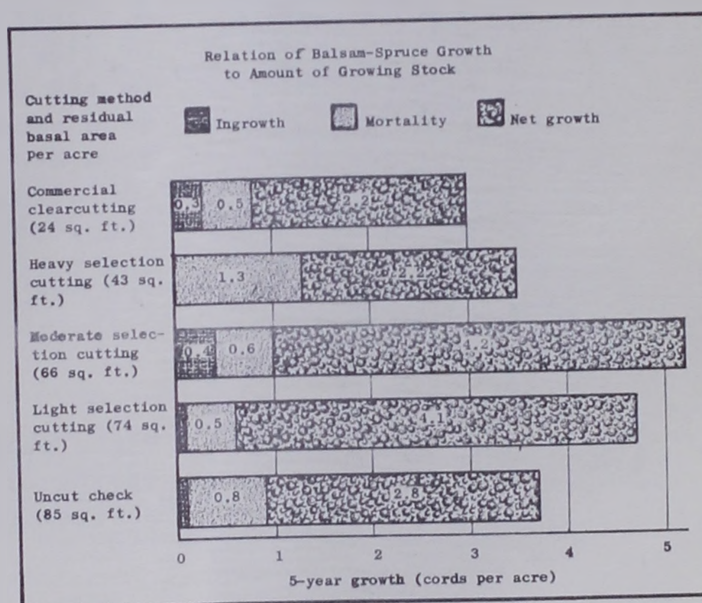
Balsam Fir-Spruce

Natural succession in a number of temporary types will produce stands with a high proportion of balsam fir and spruce. On many areas this succession is desirable and will be encouraged by removal of the overstory (often aspen) in commercial logging. Recognizing this possibility, cutting studies were started several years ago to determine the management methods to be used in handling balsam fir-spruce stands.

Moderate Selection Cuttings Give Good Growth

Five-year measurements, admittedly a short period in testing any management method, indicate that moderate stocking of from 65 to 75 square feet of residual basal area after selection cutting gave better growth than either lighter or heavier residual stands. With this basal area stocking, annual growth was slightly over 0.8 cord per acre.

Growth declined and mortality generally increased when the level of growing stock was either greater or less than this mid-level (see chart).



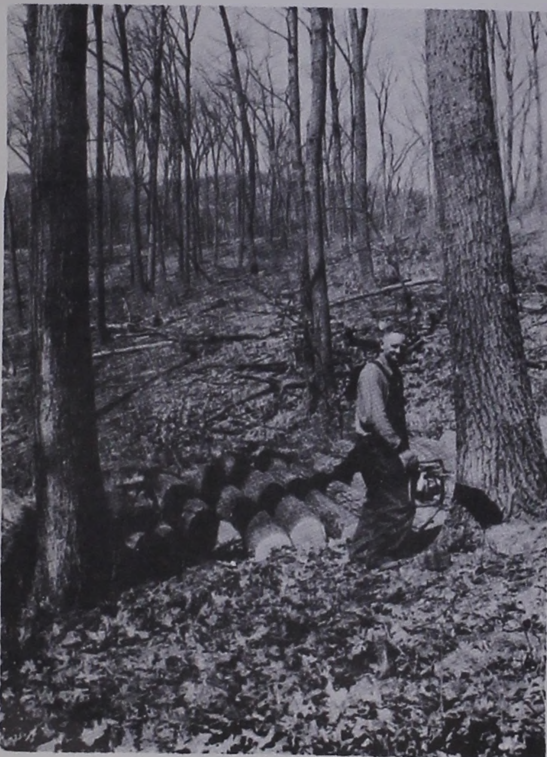
The opening up of the stand has brought about a significant change in the potential balsam fir growing stock (seedlings 1 foot and taller) in the 5 years since logging. Seedlings of this size have increased from 1,800 to 5,500 per acre on the moderate selection and heavier cutting but from 2,000 to only 2,700 per acre on the light-selection cutting.

Oak

The oak stands of the Lake States, lying mostly in the southern farming area of the region, represent a resource of considerable magnitude. Interspersed in the farm land as small woodlots, the timber is highly accessible and might well be managed intensively to yield products of high unit value. Unfortunately, we do not know the best means of handling this resource. Present research is aimed mainly at discovering the factors that influence regeneration and methods of replacing mature stands with vigorous seedling stands with a high proportion of valuable red oak.

Reproduction of Oak Under Shelterwood Cutting

One of the compartments of the Hardies Creek Timber Harvest Forest, a research area maintained in Trempealeau County in cooperation with the Wisconsin Conservation Department, was given the second scheduled shelterwood cutting early in 1956. The basal area of sawtimber trees has thus been reduced from 147 square feet in the original stand before cutting in 1950 to 64 square feet after the second cutting. Suppressed, intermediate, and low-quality dominant and codominant oaks and undesirable species were removed in the two cuttings.



The number of oak seedlings less than 9.5 feet tall increased from 858 in the original stand to 2,355 in early 1956. On the other hand, the number of hardwood seedlings of other species decreased from 878 to 701 in the same period. Observations will be continued on this case study to give leads for future research and for proper cutting to encourage seedling reproductions of oak.

Mixed oak stand in the early spring of 1956 after a second shelterwood cut had been made.

Rodent Damage Heavy in Oak in 1955-56

Some of the oak seedlings on the Hardies Creek Experimental Forest have been under observation since their establishment in the spring of 1952 to determine the importance of rodent damage to oak reproduction. During the first 4 years of observation the amount and severity of depredations by mice and rabbits were negligible. However, during the winter of 1955-56, when peak populations of both rodents were reached, about 66 percent of all the red oak seedlings were cut back or girdled. A limited sample of 50 trees measured in late July of 1956 showed that the sturdy root systems of the seedlings permitted them to make good recovery. Seedlings which had been cut back to an average height of 3.6 inches had attained an average height of 11.6 inches 3 months later. This study will be continued to observe growth and any future damage that may occur.

Northern Hardwoods

The Station's program in the northern hardwood type has been strengthened through additional research in second-growth stands. The current trend toward greater use of northern hardwoods of pulping size emphasizes the importance of adding to our knowledge of the effects of various cutting practices in younger timber. Established studies in old-growth stands continue to add to the fund of information basic to production of quality sawtimber.

Growing Stock Levels- Tree Quality Study Established

A study to determine the effects of various growing stock levels in northern hardwood poletimber stands on (a) growth and (b) stem quality is being started in northern Wisconsin by the Northern Lakes Research Center. The first of three replications is currently being installed on the Argonne Experimental Forest.

Treatments under test combine initial cuts, leaving 40, 60, 80, and 100 square feet residual basal area per acre in trees 3.6 inches and up, with final stocking levels of 40, 60, 80, and 100 square feet. Thus, for example, a comparison eventually can be made among stands reaching 100 square feet which were initially cut to 40, 60, 80, and 100 square feet.

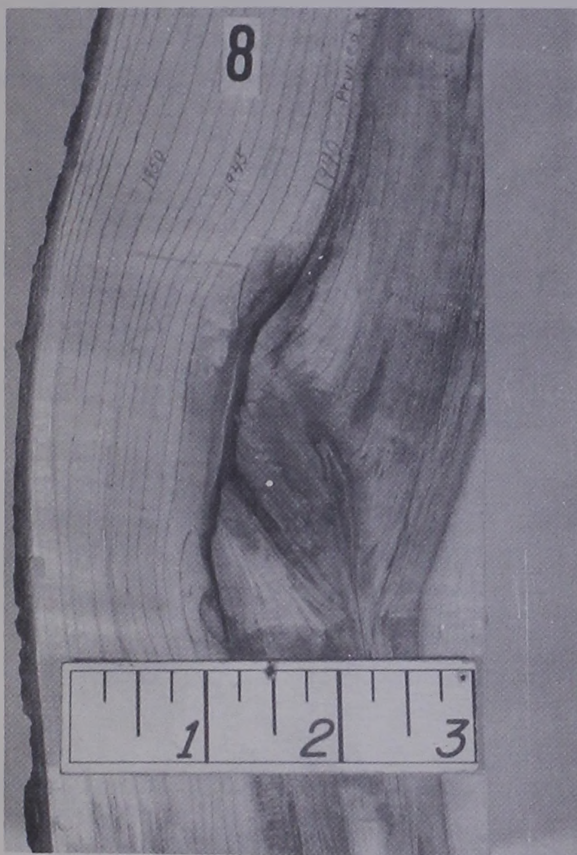
An accurate record of changing stem quality under each treatment will be available in the future from stem diagrams of sample trees made to a height of two logs or to the beginning of the live crown, whichever occurs first. Defects, epicormic branching, and logging damage are expected to differ by treatment because of changes in growth rate, light conditions, and varying logging intensity.

Hardwood Pruning Studied

During the winter of 1939 a study was initiated to determine the feasibility of pruning northern hardwoods to produce higher quality knot-free products. At the time of pruning the 11-year-old trees averaged about 2 inches in diameter. By 1947 nearly all the pruning wounds had healed over and the trees, now 6 to 10 inches in diameter, were producing clear wood.

Some of these wounds on sugar maple and elm were dissected to learn the relationship of hardwood pruning to stem decay. Preliminary results indicate that artificially pruned branches in trees of this size have slightly less decay than those pruned by nature.

Pruning has been most beneficial in thinned stands because rapid natural pruning usually takes place in dense unthinned young stands. This study has shown that the height to the first limb of unpruned trees in unthinned stands equaled that of pruned trees after 16 years; in thinned stands unpruned trees were more limby than pruned ones.



Pruning wound in 1956 after 17 growing seasons. Scar is still evident on exterior although wound has healed over. Interior view shows healing process and clear wood produced.

Improvement cutting through harvesting of hardwood pulpwood and chemical wood from pole stands combined with judicious pruning holds much promise for producing quality hardwoods.

Increased Yields Resulting From Charcoal Production

Utilization of hardwood chemical wood and pulpwood will greatly increase the yield of merchantable products from many northern hardwood stands. This is illustrated by an experimental cutting in northern Wisconsin where logs, pulpwood, and chemical wood were harvested. Customary utilization would have taken 600 board-feet of hardwood sawlogs and 1½ cords of softwood pulpwood per acre, but, by the sale of hardwood pulpwood and chemical bolts, the volume utilized was more than doubled. Furthermore, most of the additional trees harvested were of poor quality and would have been left to compete with better trees unless removed in stand improvement cuttings requiring a cash outlay.

Proper Seedbed Preparation Favors Yellow Birch Reproduction

Seedbed scarification not only increases the catch of yellow birch seedlings but also enhances survival and early growth. Three years after disk-ing the number of yellow birch seedlings is correlated with the percent of mineral soil exposed and a large number are still dominant over competing vegetation.

Exposure of 75 percent of the mineral soil appears to be the optimum to obtain the highest stocking, survival, and growth (see table). This seedbed condition will virtually assure an increase in the proportion of the yellow birch in the stand, provided that a good seed source is available. Complete exposure of mineral soil was slightly less favorable than 75 percent exposure but better than 50 percent exposure. With only 25 percent of the mineral soil exposed, the effectiveness of treatment is rapidly lost and is not apparent at the end of 3 years.

Stocking and growth of yellow birch seedlings
3 years after disking treatments

Amount of mineral soil exposed (percent)	Percent of quadrats stocked	Number of seedlings per acre		
		All seedlings	6-12 inches tall	12-36 inches tall
0	45	14,000	5,000	2,000
25	53	12,000	6,000	1,000
50	62	74,000	35,000	13,000
75	77	152,000	89,000	21,000
100	67	121,000	64,000	13,000

One of the chief advantages of scarification is the elimination or reduction of grass and shrub competition until the reproduction becomes well established. Under heavy cutting of the overstory as practiced on this test area, an abundance of grasses and shrubs developed on all seedbeds within 3 years, but the yellow birch is well established by this time and largely in a dominant position. Under favorable conditions of partial shade and moisture, yellow birch is tall enough to compete with the rapidly growing shrubs that would overtop it in the absence of disking.

Shade studies indicate that a moderate cutting, leaving a stand heavy enough to give about 50 percent shade, is effective in increasing the height growth of the birch seedlings and in reducing grass and shrub competition.

Top-Dying in Yellow Birch

Top-dying in yellow birch in the Upper Peninsula of Michigan, first observed in the spring of 1954, became more severe in heavily cut stands during 1956 but declined in the virgin and moderately cut stands following initial intensification in 1955.

The table on the following page shows the results of measurement made in 1954, 1955, and 1956. In heavily cut stands all size classes show an increase in number of injured trees and an intensification of damage in 1955 and 1956. The very few trees that show improvement after heavy cutting are confined almost entirely to the smaller sizes. In 1956 the 5- to 9-inch diameter class shows the greatest percent of uninjured trees, 15 percent; the 10- to 14-inch class had only 11 percent uninjured trees, and all trees in the 15-inch class have some damage. Mortality has now occurred to some extent in all of the diameter classes.

In contrast, all size classes of trees in the virgin and moderately cut stands show an increase in the proportion of the trees with no injury in 1956. Again, the smallest diameter class shows the highest proportion of uninjured trees, 68 percent, with decreasing proportions in the larger diameter classes. Mortality has occurred in the 10- to 14-inch class.

The initial cause of the top-dying may have been due to a high water table during the beginning of the growing season of 1954 that resulted in root-let mortality. From late March to early June of that year water tables remained high with minor fluctuations rather than declining steadily from a high in early April as they normally do. Water level recorders are now being established under several forest conditions to determine water table fluctuations under a variety of cutting methods.

Top-dying in yellow birch, by injury class and year

Kind of stand	D.b.h. class (inches)	Number of trees	Year of measurement	Percent of trees ^{1/--}				
				Not injured	Slightly injured	Moderately injured	Severely injured	Dead
Virgin and moderately cut	5- 9	41	1954	78	5	7	10	-
			1955	53	10	32	5	-
			1956	68	3	24	5	-
	10-14	50	1954	42	40	14	2	2
			1955	20	34	42	-	4
			1956	56	2	38	-	4
	15+	89	1954	16	49	33	2	-
			1955	10	16	71	3	-
			1956	22	6	70	2	-
Heavily cut	5- 9	55	1954	31	29	26	9	5
			1955	35	13	38	7	7
			1956	15	9	65	4	7
	10-14	48	1954	38	37	21	-	4
			1955	23	38	33	2	4
			1956	11	4	79	2	4
	15+	26	1954	23	23	46	8	-
			1955	8	19	62	11	-
			1956	-	8	80	8	4

^{1/} Slightly injured: Trees with abnormally small curled or yellowish foliage and/or partial defoliation of twigs. Moderately injured: Trees with dead twigs and/or dead branches constituting less than one-half of the crown. Severely injured: Trees with over one-half of the crown dead but at least one trunk sprout.

Water table recorder in operation on heavily cut area.



Aspen

Although some of the aspen type is slowly converting to other forest types through natural succession, sometimes hastened by cutting operations, the large aspen acreage of the Lake States continues to increase in importance as a source of wood. It is now the leading pulpwood species; large diameter aspen are eagerly sought for match bolts, veneer, and lumber. On sites to which it is well adapted, aspen reproduction and growth are now encouraged by many landowners. Although the total aspen area of the region will decline somewhat in the future, the desirable technical properties of the tree and its rapid growth will assure it an important place in the wood supply of the future.

Experimental work with aspen in northern Minnesota has progressed sufficiently so that two management conferences of 2-day duration were held last summer in the field to show results of good management practices in aspen and discuss the latest recommendations. These conferences were well attended by representatives of both public and private agencies that are interested in proper handling of their aspen lands.

Growth of Aspen Reproduction

The lack of information concerning the effect of stand density on the growth of aspen suckers prompted the establishment of a sucker density study in 1952. Stocking densities of 260, 500, 1,000, and 1,500 trees per acre were established by thinning a 1-year-old stand of suckers that had resulted from clear cutting mature timber on a good site.

Five annual measurements since that time show that stand density has had little effect on height growth. This work also disclosed that when aspen sucker stands are thinned immediately after establishment, additional suckering can be expected for at least 3 years. Although results to date indicate that early thinnings have no pronounced benefits in management of very young stands, observations over another 5-year period should furnish valuable information on the methods of handling such stands and on the density needed to obtain full stocking of quality stems at older ages.

Early Thinning on Good Aspen Site Increases Yield

Studies established on the Pike Bay Experimental Forest in northern Minnesota in 1936 and 1939 show that stand improvement work on good sites will increase aspen stand quality by increasing both the volume in large trees and the volume of wood available per acre. One area thinned at 13 years of age had 21 percent more volume in trees 6 inches d.b.h. and larger after 20 years than comparable unthinned stands. Also, 22 percent of the volume in the untreated area was made up of cull trees; such trees had been eliminated in the thinned stand.

Cutting Methods Study in Aspen-Balsam Stands

Mature aspen and paper birch stands with balsam fir and spruce understories are common in the Lake States. One such stand in northern Wisconsin was cut in four different ways in 1950 to determine the comparative merits of various methods and degrees of cutting the overstory hardwoods.

Site conditions on the study area are medium to good for aspen. The overstory was composed of aspen and paper birch ranging up to 12 inches and averaging 6 inches in diameter. Balsam fir, black spruce, and white spruce averaging 3 inches in diameter made up the understory. Before cutting the stand averaged 100 square feet of basal area per acre. Three-fourths of this total was in the aspen-birch overstory and one-fourth in the understory balsam fir.

Five years after cutting the growth on the understory balsam was 95 cubic feet per acre per year on the area where the merchantable aspen overstory was clear cut. Annual growth for the area where only those trees yielding three pulpwood sticks or more were removed was 68 cubic feet per acre. Where none of the overstory was removed the balsam growth was only 35 cubic feet per acre per year.

Mensuration

Tree Volume Formulas Developed

During the past decade many routine tabulating and computing jobs in forestry have been adapted to handling with punchcards and automatic business machines. As a result, there has been considerable demand for volume formulas for use in these machines that would permit close interpolation for diameter and height increments. To meet this demand the standard composite volume tables have been converted to a factorial basis that can be easily handled by business machine methods. These formulas are:

Volume in standard cords = a.b.c.

Volume in board-feet (International $\frac{1}{4}$ -inch rule) = a.b.c.d.

where $a = \frac{D^2}{1000}$; $b = \frac{190 + D}{100}$; $c = \frac{n^2 (21-n) + 4}{100 n}$; $d = 475 + \frac{3n^2}{2}$;

and where D and n are tree diameter at breast height (in inches) and number of 8-foot bolts contained in the merchantable bole, respectively.

Plans for 1957

Important soil-site relations studies will be sufficiently advanced in 1957 to permit analysis of the field data and publication of some of the results. Results of aspen studies should appear during the year.

The genetics field center at Rhinelander, Wis., will be equipped for research in genetics and tree physiology; studies involving photoperiodism, resistance to cold, flower formation, and summerwood formation will be undertaken.

New projects in the economics of forest management will be under way in 1957. A new staff member in Minnesota will review records of management costs and returns on a pine management unit and a black spruce management unit for which considerable information has been collected during the past years. The Station is also taking part in a study of the economics of production of eastern white pine.

Studies of cutting methods and stocking levels to be maintained for best growth will be installed in jack pine in the Lower Peninsula of Michigan. Work in management of second-growth northern hardwoods will be actively advanced also.

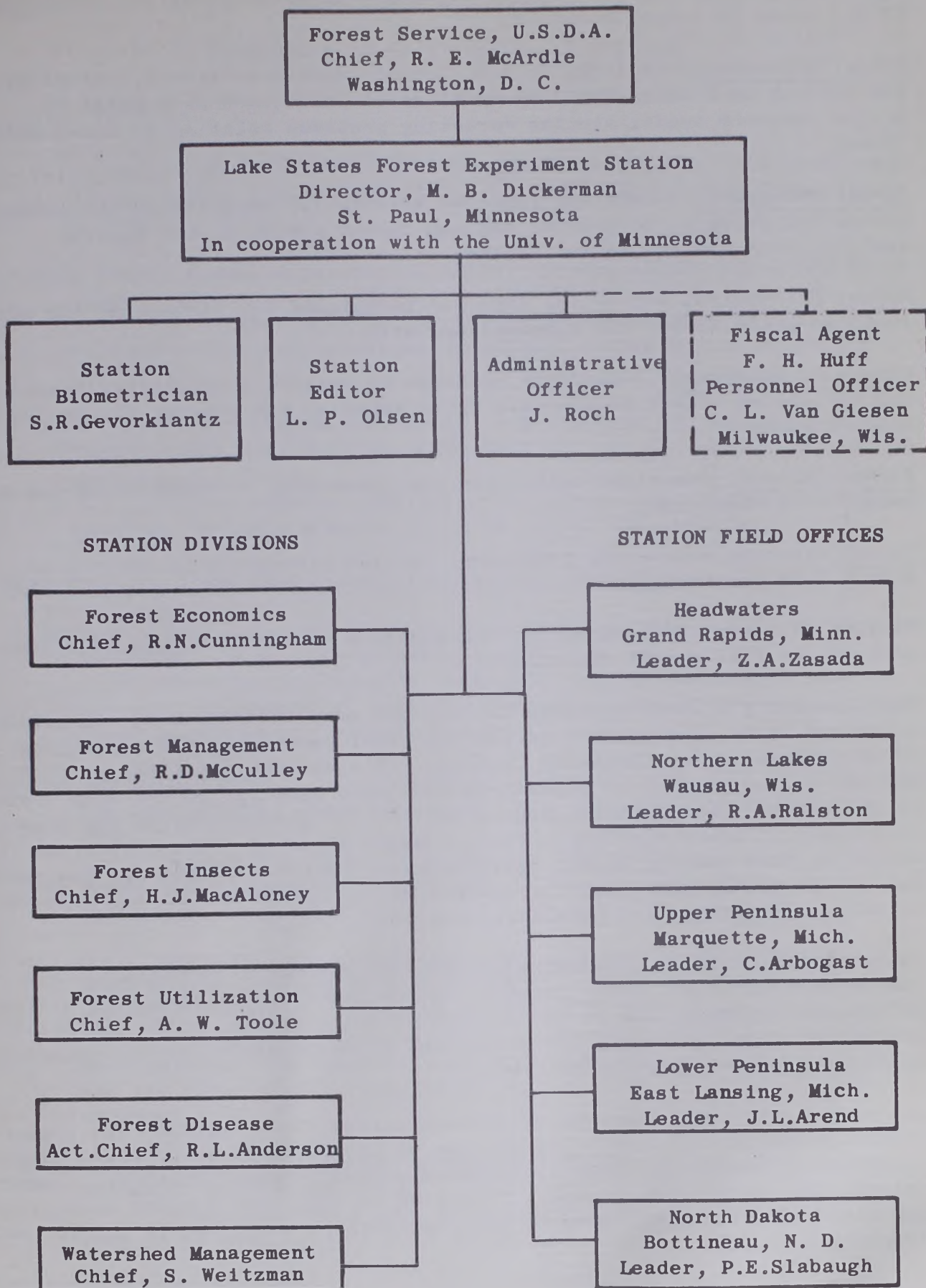
Existing experimental installations will require a large portion of the staff's work in forest management. Results of these long-term studies will be published as they become available.

S T A T I O N O R G A N I Z A T I O N

Frequently someone asks, "How is the Station organized," "What kinds of research do you do," or "Where are your field offices and how are they tied in to the Station headquarters in St. Paul?" These questions undoubtedly have grown out of the addition of new programs and new field offices and come from the many new groups we are dealing with in these various activities. Certainly in recent years the Station organization has become more complex and the need for an understanding of the organization is more urgent. For this reason, the following material on Station organization has been developed.

The Lake States Forest Experiment Station is a regional office of the Forest Service, U. S. Department of Agriculture. Our headquarters are at the University of Minnesota, St. Paul Campus. Through Federal legislation we are authorized to conduct forest research for the benefit of all forestry agencies, including public forest services, wood-using industries, farmers, and other forest owners in the area. Many of our studies are in cooperation with one or more representatives from these groups.

ORGANIZATION OF THE LAKE STATES FOREST EXPERIMENT STATION



Under the guidance of the Station Director, major programs are conducted in six areas of forest research:

Forest Economics.--Analyzes data on forest inventory, growth, mortality, and cutting as a basis for industrial development, and as a guide to future research needs; studies marketing problems relating to low-quality timber.

Forest Management.--Develops improved methods for managing forest lands, public and private, to provide maximum timber yields of the desired quality, both now and in the future.

Forest Utilization.--Develops improved techniques for harvesting and utilizing low-grade timber and eliminating waste.

Watershed Management.--Conducts research on methods of planting, managing, and harvesting timber to conserve water supplies and prevent floods and soil erosion.

Forest Insects.--Develops techniques for preventing or controlling insect damage on forest trees.

Forest Diseases.--Develops techniques for the prevention or control of forest tree diseases.

Working with the Station, but not responsible to the Director, is a biologist of the Fish and Wildlife Service.

The Director's Office, Division Chiefs, and some Project Leaders are headquartered in St. Paul. Most of the technical personnel, though, are at field offices, called Research Centers. This enables the staff at each Center to keep abreast of conditions and needs peculiar to the area served by the Center. For example, nearly half of the plantations in the Lake States are in Lower Michigan. Thus, a major field of research for the Center at East Lansing is the establishment, cultural treatment, and management of plantations, and the control of the insect and disease attacks to which plantations are peculiarly subject.

The staff at a Center is usually composed of a team of specialists from one or more Divisions. The Research Center Leader is in immediate charge of research projects and is responsible to the Director, while the Division Chief gives technical leadership and is responsible for coordination of activities in a particular field.

Advisory committees, composed of representatives from industry and conservation groups, consult with the Station on the problems of greatest importance and advise on the kind of research needed. Forest research, conservation, and educational groups are invited to visit our Station headquarters and field offices to see some of the experimental work, and to consult on forestry problems.

Lake States Forest Experiment Station

General Forestry

Dickerman, M. B. REVIEW OF "FOREST AND RANGE POLICY: ITS DEVELOPMENT IN THE UNITED STATES," BY SAMUEL T. DANA. Jour. Farm Econ. 38: 1075-1077. 1956.

- * Lake States Forest Experiment Station. ANNUAL REPORT FOR 1955. 85 pp., illus. (Processed.) 1956.

(Describes briefly the Lake States timber situation, new Station activities, progress on current projects, and plans for 1956.)

- * Olsen, L. P., and Woodworth, H. A. PUBLICATIONS OF THE LAKE STATES FOREST EXPERIMENT STATION, 1923-1955. L. S. Sta. Paper 39, 130 pp. (Processed.) 1956.

(Lists publications by author within subject matter classifications; includes special lists of serial publications.)

Regeneration, Stand Improvement, and Harvest Cuttings

- * Arbogast, Carl, Jr. BASIC PRINCIPLES OF FOREST MANAGEMENT IN NORTHERN HARDWOODS. 6 pp. (Processed.) 1956.

(Reviews in layman's terms the recommended practices for all-aged management of northern hardwoods, and how to develop the ideal stands in our present forests.)

Arend, J. L. CONTROL OF UNDESIRABLE HARDWOODS IN FOREST MANAGEMENT IN THE LAKE STATES. Weed Soc. Amer. Abstracts (1955 meeting): 34. 1956.

(Describes chemical herbicide treatments recommended for controlling undesirable hardwoods in the Lake States for forest management purposes.)

- * Conover, David F. HARVESTING CHEMICAL WOOD AND PULPWOOD MORE THAN DOUBLES USUAL YIELDS FROM IMPROVEMENT CUTTING IN SECOND-GROWTH NORTHERN HARDWOODS. L. S. Tech. Note 459, 2 pp. (Processed.) 1956.

(In a case history study of a logging operation where hardwood pulpwood and chemical wood were harvested along with sawlogs and tie cuts, yields were increased and value to residual stand enhanced.)

- * Gevorkiantz, S. R. MANAGING HARDWOODS FOR QUALITY INCREMENT. Jour. Forestry 54: 837-840, illus. 1956.

(The need for a more factual and systematic basis for appraisal of quality increment is discussed.)

* Available for distribution.

Guilkey, Paul C., and Westing, Arthur H. EFFECTS OF INITIAL SPACING ON THE DEVELOPMENT OF YOUNG JACK PINE IN NORTHERN LOWER MICHIGAN. Mich. Acad. Sci., Arts, and Letters Papers XLI (1955 meeting): 45-50. 1956.

(This study demonstrates the effects of stand density on the growth of jack pine at age 15 years. The diameter growth of all trees had been impaired at spacings less than 3x3 feet. Height growth of dominants was not affected by stand density. Spacings of 5x5 feet to 7x7 feet are satisfactory for both growth and development until commercial thinnings can be made.)

* Ralston, Robert A., and Lemmien, Walter. PRUNING PINE PLANTATIONS IN MICHIGAN. Mich. State Univ. Agr. Expt. Sta. Cir. Bul. 221, 28 pp., illus. 1956.

(Outlines recommended pruning practices and methods for pine plantations. Covers need for pruning, tools, systems adaptable to various growth conditions, and possible financial returns. It presents the results of research in terms for the layman.)

* Rudolf, Paul O. 1955 FOREST SEED CROP GENERALLY FAIR IN THE LAKE STATES. L. S. Tech. Note 447, 2 pp. (Processed.) 1956.

(Seed crops for the principal forest tree species are listed in percent of full crops for northern Minnesota, northern Wisconsin, Upper Michigan, and Lower Michigan.)

* _____ TREE PLANTING IN LOWER MICHIGAN SANDBLOWS. Minn. Acad. Sci. Proc. 22 (1954 meeting): 85-90. Published 1956.

(Ten years after planting on a large sandblow, jack pine, Scotch pine, red pine, and pitch pine have grown and survived best. Brush broadcast between plants has improved growth, especially of white pine, white ash, hybrid poplars, and red oak.)

* _____ and Watt, Richard F. CHEMICAL CONTROL OF BRUSH AND TREES IN THE LAKE STATES. L. S. Sta. Paper 41, 58 pp., illus. (Processed.) 1956.

(Reviews recent developments in chemical control of Lake States woody plants as reported in the literature.)

* Stoeckeler, J. H., and Macon, John W. REGENERATION OF ASPEN CUTOVER AREAS IN NORTHERN WISCONSIN. Jour. Forestry 54: 13-16, illus. 1956.

(A survey of 46 cutover aspen stands in northern Wisconsin shows that the number of stems in the form of new regeneration is dependent primarily on how completely the overstory is removed, and on the years since logging. Site index of the original stand and season of logging had some effect. Considerable natural conversion is occurring to other species on the better sites.)

and Scholz, H. F. A CYLINDRICAL SCREEN FOR PROTECTING DIRECT SEEDINGS OF FOREST TREE SPECIES. Jour. Forestry 54: 183-184, illus. 1956.

(Several types of cylindrical screens to protect experimental direct seedings from rodents and birds are described. A special tool for setting the smaller screens is also discussed.)

Forest Genetics

Nienstaedt, Hans. THE FOUNDATION FOR SPRUCE IMPROVEMENT IN THE LAKE STATES. Wis.-Mich. Sect. Soc. Amer. Foresters, pp. 17-28. (Processed.) 1956.

(A discussion of some of the methods used and results obtained in tree improvement work over the last decades. The characteristics of superior spruce trees are described in some detail.)

RECEPTIVITY OF PISTILLATE FLOWERS AND POLLEN GERMINATION TESTS IN THE GENUS CASTANEA. Zeitschr. f. Forstgen. u. Forstpflanzenzuchtung 5: 40-45. 1956.

(The Japanese and Chinese chestnuts studied were protandrous. Female flowers are receptive 5-13 days after beginning of anthesis of male catkins. Effects of emasculation on nut yield were studied and chestnut pollen germination techniques explored.)

* Rudolf, Paul O. GUIDE FOR SELECTING SUPERIOR FOREST TREES AND STANDS IN THE LAKE STATES. L. S. Sta. Paper 40, 32 pp., illus. (Processed.) 1956.

(Prepared for the Lake States Forest Tree Improvement Committee, this paper discusses the traits of forest trees generally considered to reflect heredity strongly. Special traits to be sought are listed for a number of individual species.)

LAYING THE FOUNDATION FOR FOREST TREE IMPROVEMENT IN THE LAKE STATES. Wis.-Mich. Sect. Soc. Amer. Foresters Proc., pp. 1-7. (Processed.) 1956.

(Brief discussion on forest tree improvement--what it is, how it is done, activities in the Lake States and similar regions, applications, and future prospects.)

* Santamour, Frank S., Jr., and Nienstaedt, Hans. THE EXTRACTION, STORAGE, AND GERMINATION OF EASTERN HEMLOCK POLLEN. Jour. Forestry 54: 269-270. 1956.

(Long daylength (20 hours) is beneficial in extraction of hemlock pollen from branches collected 3 months before normal pollen shedding. Hemlock pollen was stored successfully at 50 percent relative humidity and 1° to 16° C.)

* Stoeckeler, J. H., and Rudolf, Paul O. WINTER COLORATION AND GROWTH OF JACK PINE IN THE NURSERY AS AFFECTED BY SEED SOURCE. Zeitschr. f. Forstgen. u. Forstpflanzenzuchtung 5: 161-165, illus. 1956.

(Winter foliage coloration of 1- to 3-year-old jack pine nursery stock from 29 seed origins in the Lake States was strongly correlated with latitude and number of degree days over 50° F. of locality of seed origin.)

Shelterbelts

- * Watt, R. F. SEVERE WINTER DAMAGE TO CONIFERS NOTED IN PORTIONS OF NORTH DAKOTA, 1955-56. L. S. Tech. Note 466, 2 pp. (Processed.) 1956.

(Reports species damaged and type of injury to shelterbelts resulting from adverse climatic conditions.)

Soils and Water

- * Dils, Robert E., and Arend, John L. SNOW ACCUMULATION UNDER RED PINE OF DIFFERENT STAND DENSITIES IN LOWER MICHIGAN. L. S. Tech. Note 460, 2 pp., illus. (Processed.) 1956.

(Measurements show that depth of snow accumulation decreased as stand density increased; the intercepted snow was lost by evaporation and sublimation.)

Fire

- * LaMois, Loyd M. PINE PLANTATIONS OFFER FIRE PROTECTION PROBLEMS IN LAKE STATES. L. S. Tech. Note 462, 2 pp. (Processed.) 1956.

(Compares occurrence, average size, and per-acre damage of fires in pine types to other stocked timber types in the region, and relates the information to problem of plantation protection.)

Forest Insects

- Batzer, H. O. TIP AND WOOD FEEDING INSECTS OF MINNESOTA. In Abstract of Tree Protection Short Course, Univ. Minn. Inst. Agr., pp. 21-26. (Processed.) 1956.

(A brief resume of tip and wood feeding insects attacking ornamentals and foundation plantings, and methods of control.)

- * _____ and Waters, William E. FOREST TENT CATERPILLAR. U. S. Forest Serv. Forest Pest Leaflet 9, 4 pp., illus. 1956.

(A brief account of the life history and habits of the insect, and suggestions for its control and for preventing damage.)

- Bean, J. L. INSECTS DEFOLIATING CONIFERS IN MINNESOTA. In Abstract of Tree Protection Short Course, Univ. Minn. Inst. Agr., pp. 27-30. (Processed.) 1956.

(A brief resume of defoliating insects attacking coniferous ornamentals and foundation plantings, and methods of control.)

- * _____ RED PINE SCALE. U. S. Forest Serv. Forest Pest Leaflet 10, 4 pp., illus. 1956.

(A brief account of the life history and habits of the insect, and suggestions for its control and for preventing damage.)

- * _____ and Batzer, H. O. A SPRUCE BUDWORM RISK-RATING FOR THE SPRUCE-FIR TYPES IN THE LAKE STATES. L. S. Tech. Note 453, 2 pp. (Processed.) 1956.

(Presents a method for rating the susceptibility of a spruce-fir stand to budworm damage. Such factors as age, density, composition, area, and vigor were employed in developing the risk-rating tables.)

- Beckwith, L. C. SUCKING INSECTS OF MINNESOTA. In Abstract of Tree Protection Short Course, Univ. Minn. Inst. Agr., pp. 17-20. (Processed.) 1956.

(A brief resume of sucking insects attacking ornamentals and foundation plantings, and method of control.)

- * _____ and Anderson, R. L. THE FOREST INSECT AND DISEASE SITUATION, LAKE STATES, 1956. L. S. Sta. Paper 42, 26 pp., illus. (Processed.) 1956.

(A cooperative report based on surveys conducted by Federal, State, and private agencies in 1956.)

- * _____ and Drooz, A. T. TAMARACK MORTALITY IN MINNESOTA DUE TO LARCH SAWFLY OUTBREAK. Jour. Forestry 54: 268-269. 1956.

(Brings together information on initial tamarack mortality due to larch sawfly defoliation in the current outbreak.)

- _____ and Ewan, H. G. THE FOREST INSECT SITUATION, LAKE STATES, 1955. L. S. Sta. Paper 35, 15 pp., illus. (Processed.) 1956.

(A cooperative report based on surveys conducted by Federal, State, and private agencies in 1955.)

- Benjamin, D. M., and Beckwith, L. C. AN EVALUATION OF SARATOGA SPITTLEBUG POPULATION ESTIMATION TECHNIQUES. No. Central Branch Ent. Soc. Amer. Proc., XI Ann. Meeting, pp. 19-20. 1956.

(Describes a refinement in survey procedure that could be used in nymphal surveys of the Saratoga spittlebug. The method could be applied to surveys of other insects exhibiting the same general life cycle.)

- * Drooz, Arnold T. THE LARCH SAWFLY. U. S. Forest Serv. Forest Pest Leaflet 8, 4 pp., illus. 1956.

(A brief account of the life history and habits of the insect, and suggestions for its control and for preventing damage.)

- * _____ and Benjamin, D. M. PARASITES FROM TWO JACK-PINE BUDWORM OUTBREAKS ON THE UPPER PENINSULA OF MICHIGAN. Jour. Econ. Ent. 49: 412-413. 1956.

(An outbreak of the jack-pine budworm (Choristoneura pinus Free.) covering about 7,200 acres in Upper Michigan was investigated for parasites of the larvae and pupae in 1953. Highest larval parasitism was effected by Aplomya caesar (Ald.), 4 percent. Highest pupal parasitism was caused by Itoplectis conquisitor (Say), 21 percent.)

- * Ewan, H. G. A METHOD FOR MEASURING THE INSECT POPULATION ON TREES 6 TO 12 FEET TALL. L. S. Tech. Note 455, 1 p., illus. (Processed.) 1956.

(A description of a large plastic tent which can be dropped over a tree and filled with an insecticide to determine the insect population.)

- * Godwin, Paul A., and Bean, James L. PREDICTING EMERGENCE OF THE WHITE-PINE WEEVIL FROM HIBERNATION. Forest Sci. 2: 187-189, illus. 1956.

(A reasonably accurate and usable basis for estimating the degree and rate of weevil emergence in the spring is presented. Using 40° F. air temperature as the threshold of upward movement, cumulative degrees between 6 a.m. and 6 p.m. were closely correlated with the percent of weevil emergence.)

- * MacAloney, Harvey J., and Drooz, Arnold T. THE JACK PINE BUDWORM. U. S. Forest Serv. Forest Pest Leaflet 7, 4 pp., illus. 1956.

(A brief account of the life history and habits of the insect, and suggestions for its control and for preventing damage.)

Miller, William E., and Neiswander, Ralph B. THE PITCH TWIG MOTH AND ITS OCCURRENCE IN OHIO. Ohio Agr. Expt. Sta. Res. Bul. 779, 24 pp., illus. 1956.

(Discusses the geographic distribution, hosts, seasonal history, importance, and control of the pitch twig moth, Petrova comstockiana (Fernald).)

Forest Diseases

- * Anderson, R. L. HYPOXYLON CANCKER OF ASPEN. U. S. Forest Serv. Forest Pest Leaflet 6, 3 pp., illus. 1956.

(A brief resume of the present status of knowledge on the Hypoxylon canker problem.)

- * _____, Skilling, D. D., and Clifford, E. D. NURSERY ROOT DISEASE CONTROL BY SOIL FUMIGATION. L. S. Tech. Note 449, 1 p. (Processed.) 1956.

(A summary of studies indicating that heavy application of formaldehyde or methyl bromide shows promise for controlling nursery root rot.)

- * Godman, R. M. PROGRESS OF TOP-DYING IN YELLOW BIRCH--UPPER MICHIGAN, 1954-55. L. S. Tech. Note 444, 2 pp. (Processed.) 1956.

(Observation plots indicated a general crown deterioration, with some trees showing a trend toward recovery. Trees 15 inches and larger were the most seriously injured. The smaller trees appeared to be recovering more rapidly than the larger ones. Cut-over stands seem to be more seriously affected than virgin stands, but the evidence is not conclusive.)

Forest Wildlife

Krefting, Laurits W., and Erickson, Arnold B. RESULTS OF SPECIAL DEER HUNTS ON THE MUD LAKE NATIONAL WILDLIFE REFUGE, MINNESOTA. Jour. Wildlife Mangt. 20: 297-302. 1956.

(Discusses the results of five deer hunts with special emphasis on: Number of hunters and kill, dressed weight of deer, fawn productivity and sex ratio, and relation of hunting to age.)

_____, Hansen, H. L., and Stenlund, M. H. STIMULATING REGROWTH OF MOUNTAIN MAPLE FOR DEER BROWSE BY HERBICIDES, CUTTING, AND FIRE. Jour. Wildlife Mangt. 20: 434-441. 1956.

(Discusses regrowth produced by the butoxy ethanol esters of 2,4-D and 2,4,5-T; compares the results with fire and cutting with an axe.)

Estimation of Timber Volume, Growth, and Yield

* Gevorkiantz, S. R. SHORT CUTS IN SCALING--CONVERTING STACKED CORDWOOD TO BOARD-FEET. L. S. Tech. Note 468, 1 p. (Processed.) 1956.

(A method of converting cords to board-feet, requiring only a direct count of 8-foot bolts.)

* _____ Three Technical Notes of 2 pages each, presenting site index curves for a species and explaining their use and limitations (processed):

SITE INDEX CURVES FOR ASPEN IN THE LAKE STATES, Tech. Note 464.

SITE INDEX CURVES FOR BALSAM FIR IN THE LAKE STATES, Tech. Note 465.

SITE INDEX CURVES FOR JACK PINE IN THE LAKE STATES, Tech. Note 463.

* Hartong, A. L., and Thornton, P. L. BIAS IN TIMBER VOLUME ESTIMATES CAUSED BY ROUNDING OFF D.B.H. AND MERCHANTABLE LENGTH MEASUREMENTS. Jour. Forestry 54: 769-770. 1956.

(A study of 1,462 sample trees showed that grouping trees by 2-inch diameter classes and by half-log lengths caused over-estimates of board-foot volume by 1.19 percent and 0.92 percent, respectively.)

Timber Resource and Production Statistics

* Chase, Clarence D., and Horn, A. G. TIMBER RESOURCES OF THE BALDWIN BLOCK, MICHIGAN. Mich. Conserv. Dept., 54 pp., illus. (Processed.) 1956.

(Presents statistics on forest areas, timber volumes, growth, timber cut, and allowable cut for six counties.)

- * Cunningham, R. N. FOREST OWNERSHIP STABILIZING IN LAKE STATES. L. S. Tech. Note 448, 2 pp. (Processed.) 1956.

(A comparison of statistics on forest land ownership in 1931, 1940, 1945, and 1953 indicates a trend toward more stable ownership.)

- * _____ LAKE STATES TIMBER GROWTH INCREASING. L. S. Tech. Note 452, 2 pp. (Processed.) 1956.

(Compares growth in 1953 with 1936 and presents growth in board-feet and cubic feet for each Lake State by species.)

- * _____ and Survey Staff. LAKE STATES TIMBER RESOURCES. L. S. Sta. Paper 37, 31 pp. (Processed.) 1956.

(Basic timber resource review statistics for Michigan, Wisconsin, and Minnesota are shown in 37 tables; no text except Foreword.)

Dickerman, M. B. TIMBER AS COLLATERAL. In Outlook on Minnesota's Resources (Report of the Governor's Statewide Conference on Resources, 1955), Iron Range Resources and Rehabilitation Comn., pp. 301-306. 1956. Also "Forests Are Worth Money," Conserv. Volunteer 20(114): 14-17. 1956.

(Encouraging signs in the timber-supply situation are increased volume, increased stocking of young stands, stability of ownership, and better management of forest lands. Most unfavorable are the poor quality and the large area of nonproductive and poorly stocked forest land. Timber use needs to be increased, especially in aspen and low-grade hardwoods. Diseases and insects are greatest risk to timber supply.)

- * Horn, A. G. LAKE STATES PULPWOOD PRODUCTION SHOWS INCREASE IN 1955; CANADIAN IMPORTS DECREASE. L. S. Tech. Note 456, 2 pp. (Processed.) 1956.

(Shows production by species in Minnesota, Wisconsin, and Michigan, as well as imports from other States and Canada. Also shows movement between States in the region. Tenth of an annual series.)

- * _____ SOME HIGHLIGHTS OF PULPWOOD PRODUCTION IN THE LAKE STATES, 1946-1955. L. S. Tech. Note 457, 2 pp. (Processed.) 1956.

(Shows pulpwood production by species in Minnesota, Wisconsin, and Michigan for each year during 1946 to 1955; also averages by species and States.)

Hutchison, O. Keith, and Morgan, James T. OHIO'S FORESTS AND WOOD-USING INDUSTRIES. Central States Forest Expt. Sta. Forest Survey Release 19, 40 pp., illus. 1956.

(A presentation and analysis of statistics on the forest resource and its use in Ohio.)

- * Morgan, James T. CENTRAL WISCONSIN FOREST LANDS MOSTLY PRIVATELY OWNED. L. S. Tech. Note 451, 2 pp. (Processed.) 1956.

(Gives forest area by ownership class for a group of 13 central Wisconsin counties. Shows percentage of area in each stand-size class held by each ownership group.)

_____ and Compton, Lake F. IOWA FOREST STATISTICS. Central States Forest Expt. Sta. Forest Survey Release 20, 58 pp., illus. (Processed.) 1956.

(Shows forest areas and timber volumes for three survey units in Iowa and for the State. Standard forest survey tables are presented, with a few pages of introductory text and short summary tables.)

- * Office of Iron Range Resources and Rehabilitation and Lake States Forest Experiment Station. THE FOREST RESOURCE OF COOK CO., MINN. Office of Iron Range Res. and Rehab., 61 pp., illus. 1956.

(Presents forest areas, timber volumes, growth, allowable cut, and drain for the county.)

- * Vasilevsky, Alexander M. COMMERCIAL FOREST LAND IN MINNESOTA COUNTIES BY FOREST TYPE. L. S. Tech. Note 470, 2 pp. (Processed.) 1956.

(Forest area is shown by type for each county.)

- * _____ FOREST AREA IN MINNESOTA COUNTIES. L. S. Tech. Note 458, 2 pp. (Processed.) 1956.

(Presents total land area and commercial and noncommercial forest area by counties.)

- * Warner, John R., and Chase, Clarence D. THE TIMBER RESOURCE OF NORTH DAKOTA. L. S. Sta. Paper 36, 39 pp., illus. (Processed.) 1956.

(Describes both native and planted forests of the State, emphasizing the native forest types. Areas, timber volumes, growth, and drain for native forests are presented.)

- * Wisconsin Conservation Department and Lake States Forest Experiment Station. Eleven county reports processed in 1956 by the Wisconsin Conservation Department, each report presenting forest area, timber volumes, growth, timber cut, and allowable cut (illus.):

FOREST RESOURCES OF ASHLAND COUNTY, 37 pp.
FOREST RESOURCES OF BAYFIELD COUNTY, 37 pp.
FOREST RESOURCES OF BURNETT COUNTY, 37 pp.
FOREST RESOURCES OF CLARK COUNTY, 37 pp.
FOREST RESOURCES OF DOUGLAS COUNTY, 44 pp.
FOREST RESOURCES OF IRON COUNTY, 37 pp.
FOREST RESOURCES OF MARATHON COUNTY, 38 pp.
FOREST RESOURCES OF RUSK COUNTY, 38 pp.
FOREST RESOURCES OF SAWYER COUNTY, 37 pp.
FOREST RESOURCES OF TAYLOR COUNTY, 37 pp.
FOREST RESOURCES OF WASHBURN COUNTY, 38 pp.

Timber Utilization and Marketing

- * Boldt, Charles E., and Salminen, W. A. PERMANENT LOGGING ROADS FACILITATE ECONOMICAL TIMBER SALVAGE. L. S. Tech. Note 450, 1 p. (Processed.) 1956.

(Gives details, including areas, volumes, stumpage receipts, and mileage of access roads utilized, for seven separate salvage sales made on the Upper Peninsula Experimental Forest following tornado damage. The value of a permanent system of logging roads is emphasized by the comparatively high stumpage prices paid for windthrown timber spread thinly over large areas.)

- * Guilkey, Paul C. SHORT BOLTS OFFER BETTER HARDWOOD UTILIZATION. L. S. Tech. Note 446, 2 pp. (Processed.) 1956.

(Log scale was increased one-fourth by cutting 52-inch bolts instead of standard logs. The gain came from short clear sections of the trees that were too short for standard logs. The gain is greatest in small trees (12-inch d.b.h.) and drops off rapidly, with 18-inch trees showing no gain.)

- * _____ and Blair, Rowland W. COSTS OF CHEMICAL DEBARKING OF OAK IN LOWER MICHIGAN. L. S. Tech. Note 445, 2 pp. (Processed.) 1956.

(Both northern pin oak and white oak were treated with 40 percent sodium arsenite for chemical debarking. The total costs per cord vary more by merchantable length than by species. Chemical debarking of scrub oak costs about \$1.75 per cord when chemical cost is \$2.11 per gallon and labor costs \$1.40 per hour.)

- * Lane, Paul H., and Sprenger, Gerald E. DESIGN OF AN EXPERIMENTAL SHEET METAL CHARCOAL KILN. L. S. Tech. Note 471, 2 pp., illus. (Processed.) 1956.

(Describes a new type experimental sheet metal charcoal kiln and discusses important design features. A schematic drawing of the 3½-cord kiln is shown.)

- * Neetzel, John R., Hossfeld, Ralph L., and Otis, C. K. SMALL TREATING TANK FOR ON-THE-FARM APPLICATIONS OF WOOD PRESERVATIVES. L. S. Tech. Note 454, 2 pp., illus. (Processed.) 1956.

(Presents drawings and specifications for an inexpensive, small, on-the-farm, cold-soaking treating tank. This tank will handle lumber up to 12 inches wide, 8 inches thick, and 16 feet long. The cover also serves as a drainboard.)

- * Office of Iron Range Resources and Rehabilitation and Lake States Forest Experiment Station. MINNESOTA DIRECTORY, PRIMARY WOOD-USING INDUSTRIES. Office of Iron Range Res. and Rehab., 113 pp., illus. 1956.

(Presents a classified listing of all known primary wood-using industries in Minnesota by county, giving company name and address. A description of the sawmills as well as their market is also given.)

- * Ralston, R. A. THE BREAK-EVEN POINT FOR ROUGH 8-FOOT BOLTS MERCHANT-
ABLE AS SAWLOGS OR CORDWOOD. L. S. Tech. Note 469, 2 pp. (Pro-
cessed.) 1956.

(A table shows break-even diameters for small rough forest
products salable as cordwood or sawlogs under the Doyle, Scribner
Dec. C, and International $\frac{1}{4}$ " rules.)

- * Warner, John R. SMALL LOCAL MANUFACTURERS SUPPLY LARGE SHARE OF WOOD
PALLETES USED IN MINNEAPOLIS-ST. PAUL AREA. L. S. Tech. Note 467,
2 pp. (Processed.) 1956.

(Compares the relative importance of small and large manu-
facturers in the regional pallet industry with respect to supply
of Twin Cities demand.)

- * _____ WOOD PALLET IMPORTS IN MINNEAPOLIS-ST. PAUL AREA, 1954.
L. S. Tech. Note 461, 1 p., illus. (Processed.) 1956.

(Presents pallet volume by size of pallet, species of wood
used in manufacture, and State origin.)

- * _____ and Cowan, D. Ross. WOOD PALLETES IN THE MINNEAPOLIS-ST. PAUL
AREA: AN OUTLET FOR LOW-GRADE HARDWOODS. L. S. Sta. Paper 43,
34 pp., illus. (Processed.) 1956.

(Describes the market for wood palletes provided by the Twin
Cities metropolitan area with emphasis on use and procurement.)